NESTING HABITAT AND ECOLOGY OF ALEUTIAN TERNS ON THE COPPER RIVER DELTA, ALASKA

by

Lars H. Holtan

Final Report - Project sponsored by USDA-Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR; FS-PNW-No. 56

February 28, 1980

ABSTRACT

A study of the Aleutian tern (Sterna aleutica) was conducted during 1978 and 1979 on the west side of the Copper River Delta in southcentral Alaska. The objectives were to determine the location of colonies and of nest sites of Aleutian terns, and to describe the relationship between successional habitat changes and certain aspects of the nesting ecology of Aleutian terns. Thirty-four colonies containing 2,428 Aleutian terns were located within a vegetated strip beween the tidal mudflat and the inland region of dense shrubs and Sitka spruce. The vegetation of 10 intensively studied colonies was classified into 10 descriptive vegetation zones each of which had unique structural characteristics and represented a different level of successional development. Three vegetation zones of early seral stages composed the entire area of colonies studied in the Eyak River area in the western edge of the study area. Vegetation zones of colonies in the central and eastern portion of the study area were more diverse and represented successional stages ranging from marsh to early upland. Aleutian terns showed no selectivity for vegetation zones within colonies as locations for nests ($P<0.05$). Selection at the nest site level was demonstrated only in extreme conditions: preference for higher density cover in low density vegetation, preference for lower density cover in high density vegetation, avoidance of very wet sites, avoidance of bare ground, and avoidance of shrubs. Density of nests averaged 84.3/ha and ranged from 36.9 to 151.9 nests/ha. Dispersion of nests within colonies and within vegetation zones was largely random. In the Eyak River area, a region of

poorly defined ponds and little development of natural levees, colony sites contained vegetation with characteristics of very early successional development. In the central and eastern portion of the study area, a region of well developed pond basins and well developed natural levees, colony sites possessed vegetation with characteristics of later successional development. Although the Eyak River area was regularly flooded by spring tides and the central and eastern portions of the study area were occasionally and incompletely inundated prior to the 1964 earthquake, no portion of the delta is now covered by tides. Colonies in the Eyak River area were considered to be recently established as they were located in sites that would have been unsuitable for nesting terns prior to the 1964 earthquake. Twelve colony sites located in 1978 in the Eyak River area were still active when visited in 1979. The desertion of 7 out of 15 colony sites in the central portion of the study area in 1979 may have been caused by an increasing prevalence of shrubs. Also, two colonies in the central region within areas of the highest shrub cover, and located the furthest inland were small and had poor nest success. Colony site tenacity may be important in maintaining traditional colonies despite degradation of the habitat caused by successional change.

ACKNOWLEDGMENTS

This project was funded in its entirety by the USDA-Forest service, Pacific Northwest Forest and Range Experiment Station. Logistical support, facilities and back-up equipment were provided generously by the Cordova Work Center of the Chugach National Forest. Specifically, the cooperation and support of John Thilenius of the Forestry Sciences Laboratory in Juneau, and Richard Groff and Garvan Bucaria of Cordova USFS were greatly appreciated, especially during those periods of crisis and equipment failure that were so much a part of the field season. Inspiration, encouragement, and advise inadequately describe the positive impact of Bob Bromley on the researcher and on this project. From the conception to the completion of this study, the experience and insight of Bob Bromley provided a continuous source for the researcher. I would also like to express my gratitude to Neil Shishido for his assistance and companionship throughout the 1978 field season, and to Dan Bynon for his help during crucial times both in and out of the field. A special thanks is extended to Pete Isleib of Cordova, Alaska for sharing his home and knowledge of the delta and local avifauna. Bob Gill, USFWS, made available his accumulated store of Aleutian tern data and literature. The suggestions and reviewing of my major professor, Robert Jarvis, and of John Crawford were greatly appreciated throughout this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

NESTING HABITAT AND ECOLOGY OF ALEUTIAN TERNS ON THE COPPER RIVER DELTA, ALASKA

INTRODUCTION

The Aleutian tern (Sterna aleutica) was considered a rare bird by many (Bent 1921, Walker 1923, Murie 1936-38, Dement'ev and Gladkov 1951). Historically, the recording of colony locations was considered important, but critical data about the nesting habitat of the Aleutian tern were seldom recorded. Nelson (1887), Hersey (1920), Walker (1923), Friedmann (1933) and Howell (1948) provided only general characteristics of either colonies or nest sites. On the North American continent the Aleutian tern was recorded only in Alaska (Gabrielson and Lincoln 1959), and was described as "an uncommon local breeder in the North Gulf Coast and Prince William Sound with population estimates of several hundreds during the summer (Isleib and Kessel 1973:97). Within the last few years, R. Bromley (pers. comm.) and M. Isleib (pers. comm.) noted increased numbers of Aleutian terns on the Copper River Delta. Interest in the Aleutian tern was further stimulated when two colonies were discovered in 1975 (R. Bromley and P. Mickelson, unpubl. data), and two additional colonies were located in 1977 (R. Bromley and L. Holtan, unpubl. data) on the west side of the Copper River Delta. These observations suggested that the Copper River Delta may provide an important breeding ground in North America for Aleutian terns.

Although Aleutian terns possibly were present for some time on the Copper River Delta but only recent discovered, dramatic changes in the ecology of the area may have permitted their rapid expansion or, at the

least, brought about significant changes in distribution. As a result of the 1964 Alaskan earthquake, tectonic uplift averaging 1.89 m elevated most of the delta above the influence of tides (Reimnitz 1972). The cessation of tidal flooding with its subsequent alteration of nutrient cycling, reduction of salinity, and increased drainage of the marsh initiated significant vegetational changes that were expected to have a dramatic impact on resident and migrant wildlife populations (Crow 1968, Potyondy et al. 1975). Although most investigators predicted negative effects of these ecological changes on wildlife, especially waterfowl (Olson 1964, Shepherd 1965, Crow 1972), conditions may be becoming increasingly favorable for Aleutian terns. Because both habitat changes and disturbance factors have dramatic effects on the distribution, population levels and reproductive success of terns (Austin 1940, 1946, 1947, Hawksley 1957), it is imperative to document the current status and habitat utilization of the Aleutian tern on the Copper River Delta.

The objectives of this project were

(1) to determine the location of colonies and number of Aleutian terns on the west side of the Copper River Delta,

(2) to describe the habitat characteristics of colonies and of nest sites of Aleutian terns on the west side of the Copper River Delta,

(3) and to describe the relationship between successional habitat changes and certain aspects of the nesting ecology of Aleutian terns.

THE STUDY AREA

Located on the coast of southcentral Alaska at approximately 60°N, 145°W, the Copper River Delta encompasses an area of about 282,600 ha of which the major part still remains remote and inaccessible. The west side of the Copper River Delta, an area situated adjacent to the town of Cordova, Alaska, and transected inland by the Copper River Highway, was selected for study for logistical reasons.

Post earthquake conditions and vegetational changes on the Copper River Delta were mapped and documented by a number of investigators (Crow 1968, Reimnitz 1972, Potyondy et al. 1975, Scheierl and Meyer 1977). In a general sense, the west side of the Copper River Delta can be divided into an outer tidal zone, and an inner shrub zone. The outer tidal zone is dominated by a sedge community, although shrubs are rapidly invading the better drained areas. Near the inland zone, shrub cover increases and consists of sweetgale (*Myrica gale*), alder (*Alnus crispa*), and willows (*Salix* spp.); stands of Sitka spruce (*Picea sitchensis*) predominate on the upper portion of the inland zone. Differences are present in both vegetation and topography between western, and central and eastern portions of the outer tidal zone. The western portion of the study area in the vicinity of the Eyak River had poorly defined ponds and little development of natural levees. Central and eastern portions of the study area had well developed pond basins and well developed natural levees.

METHODS

After the arrival of Aleutian terns to the west side of the Copper River Delta, areas accessible by boat and/or foot were searched for colony locations. On 27 May and 20 June 1978 aerial surveys were conducted by flying parallel transects at 0.4 km intervals at an altitude of 46 m. The aerial survey covered 388 km^2 with most effort expended from the vegetated edge of the tital mudflat to 5-10 km inland. The offshore barrier islands were included during preliminary searches (Figure 1).

All colonies accessible from the ground were censused one or more times while birds were present. Because some colonies were located late in the nesting season after numbers of birds in other colonies had declined substantially, the actual counts of birds in colonies that were censused late in the season did not represent an accurate estimate of the maximum number of birds present. Therefore, the counts of birds in colonies that were found late were adjusted by the percent decrease (33-56%) in numbers of terns in accurately censused neighboring colonies within similar habitats.

Ten colonies (numbered 1-10) representative of different vegetative communities and locations were selected for intensive study. To minimize the effect of human disturbance, nest searching was confined to two periods: the initiation of laying by the earliest nesters, and after peak egg laying was completed. Colonies were avoided during storms or rain and were vacated by the investigators as soon as eggs became cool to the touch. The time available for continuous nest searching or data

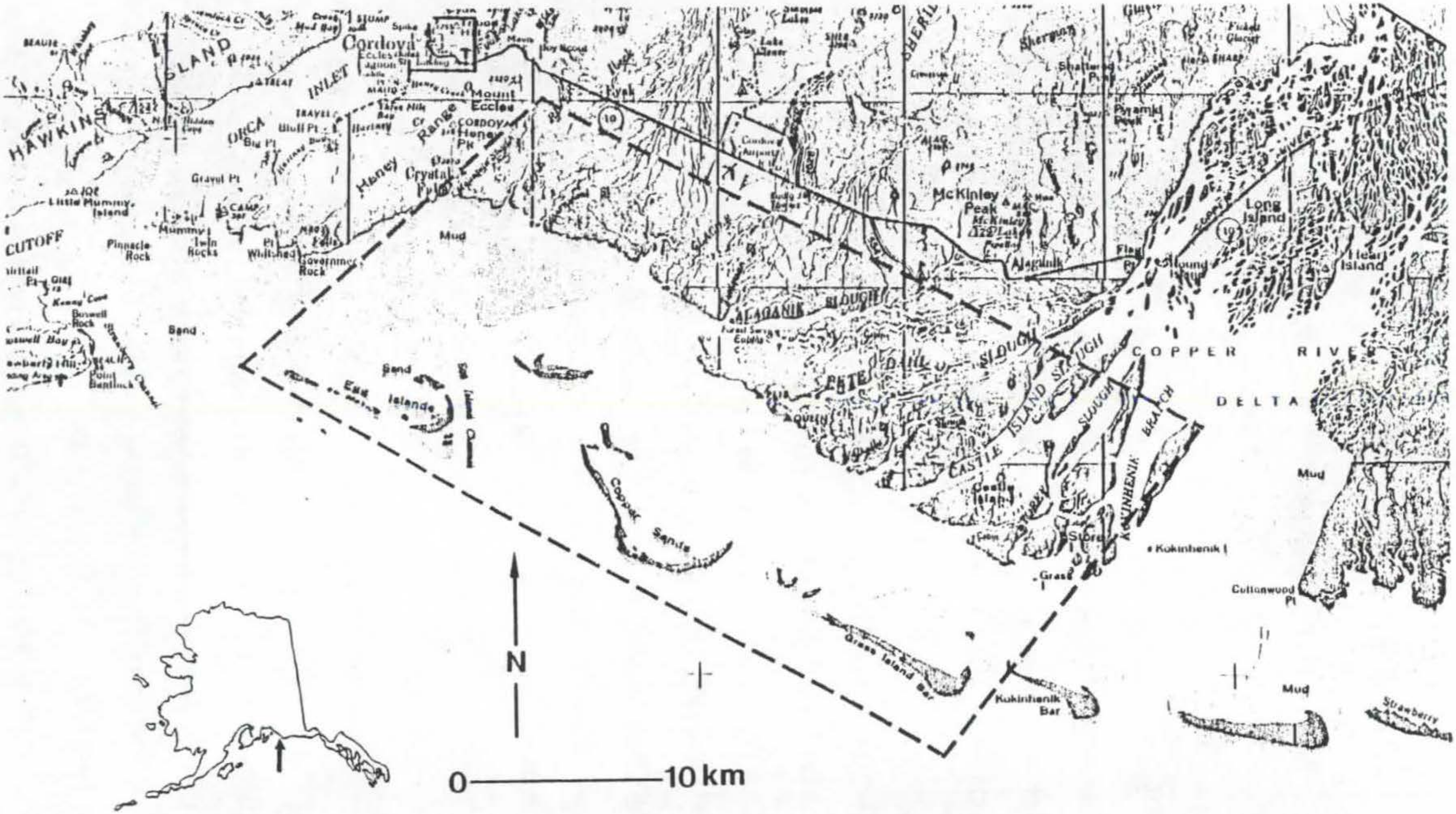


Figure 1. Map of the west side of the Copper River Delta showing the area covered by aerial survey, with an insert pointing out the relative location in Alaska.

gathering ranged from 5 to 45 minutes, depending on wind velocity, temperature, and cloud cover. A small numbered wire stake was placed 1 m to the north of each nest bowl to aid in relocating and identifying the nest.

Within 7 of the 10 intensively studied colonies, the fate of 165 nests was monitored. Daily visits were made to these colonies after the initiation of hatching on 1 June 1978 but were suspended on 11 June 1978 when I suspected that visits were having a negative effect on the survival of chicks. Because it was impossible to determine the exact fate of nests when visits were resumed 4 days later, nests that contained pipped or pipping eggs when visits were terminated were combined with nests that were observed to hatch in order to calculate hatching success. Three colonies were visited once at the initiation of hatching and again after the completion of hatching to determine the effect of human disturbance on hatching success.

Brief visits were made to 27 Aleutian tern colonies during June of 1979 to determine if these colony sites were still active. No attempt was made to locate new Aleutian tern colonies in 1979.

Nesting terns occurred as both isolated groups of nests and as clusters of groups of nests. I treated each group of nests as a colony and defined colonies as a group of three or more nests, 0.2 km or more from the next closest group of Aleutian tern nests. This distance (0.2 km) was approximately 35 times the average nearest neighbor distance between nests within colonies.

The area occupied by each colony was established by constructing a polygon around the colony based on the outermost nests plus the mean

nearest neighbor distance between nests within the colony. After the fledging of young, vegetation in each colony was sampled within 50 cm diameter plots placed systematically at 5 meter intervals throughout the colony. Percent coverage (Daubenmire 1959) and average height was recorded for cover types and species having a coverage of 5% or more in each sample plot. Because of the difficulty in separating Carex lyngbyaei from a number of grasses during early growth stages, I included it within the broader category of graminoids. Except in a few cases, where noted, Carex lyngbyaei comprised the majority if not the entirety of this general grouping. An overall density index was recorded for each plot on a scale ranging from 0 to 5, with a value of zero given to bare ground (modified from Bromley 1976). Soil moisture was estimated for each sample according to the following scale: 1 = dry, cracked, crumbling; 2 = cohesive, malleable; 3 = moist, no excess water; 4 = glistening, water visible with slight pressure; 5 = standing water present. These same measurements of vegetation structure and soil moisture were collected at nest sites.

Information gained from vegetation in systematic plots, vegetation samples at nest sites, measurements made throughout the field season, and 35 mm aerial color photos provided the basis for identifying and classifying vegetation zones within the ten intensively studied colonies. The use of the term "zone" is descriptive and is not intended to carry connotations that may have been established by previous authors. Simple vegetation maps were drawn for each colony and the areas of vegetation zones were calculated with a compensating polar planimeter. Areas of open water (ponds and sloughs) were not included as a part of colony areas.

To determine the selectivity of nest sites, nest site locations by vegetation zones were compared to the area of each vegetation zone within the colony. Comparisons were evaluated with chi-square tests of independence. Vegetation structure and soil moisture at nest sites were compared to vegetation structure and soil moisture at systematic sample plots within vegetation zones with the t-statistic. The 0.05 confidence level was used in all statistical tests.

The pattern of distribution or dispersion of nests within each colony and vegetation zone was determined according to Clark and Evans (1954). Significant departures from random expectation were determined in the direction of uniform or aggregated spacing.

RESULTS

Colony Distribution

Thirty-four colonies of Aleutian terns were located on the west side of the Copper River Delta (Table 1, Figure 2-4, Appendix VII). Twenty-eight of these colonies were visited and censused from the ground and six colonies were viewed only from the air as they were inaccessible from the ground.

Concentrations of breeding birds were found scattered along the coastal edge of most of the survey area. Aleutian tern colonies were not found on unvegetated tidal mudflats, or further inland where dense shrubs or stands of Sitka spruce predominate, but were restricted to a narrow strip (averaging 2 km wide) along the vegetated edge of the tidal mudflat. Twenty-six of the 28 colonies visited, containing 98 percent of the birds, were located within 3.6 km of the tidal mudflat (Table 2). All 34 colonies were within the general vegetation zone of well developed tidal flat and open levee described by Scheierl and Meyer (1977). The greatest concentration of both Aleutian terns and colonies was located in the Eyak River area on the western edge of the survey area (Figure 3, Areas G, H, I). Eight colonies containing 596 birds were clustered within a 1.61 km diameter circular area in this region.

Population Numbers

A total of 275 nests was located in the 19 colonies visited while incubation was still underway. Fifteen hundred and fifty Aleutian terns, presumably breeding adults, were counted. Thirteen hundred of these were

Table 1. Aleutian tern colonies present on the west side of the Copper River Delta in 1978. An adjusted bird count was calculated for colonies that were first visited late in the breeding season after numbers of birds in accurately censused colonies had declined considerably. The Area ID refers to the general colony locations shown in Figures 2, 3, and 4. Detailed colony locations are presented in Appendix VII.

Area ID	Colony Number	Maximum Observed Birds (1978)	Adjusted Count (1978)	Date First Discovered
A	1[a]	60	60	1975
B	2	55	55	1977
B	3	45	45	1 May 78
F	4	25	25	3 May 78
F	5	25	25	4 May 78
F	6	40	40	4 May 78
C	7	35	35	1977
D	8	45	45	1975
G	9	50	50	28 May 78
G	10	85	85	28 May 78
C	11	10	10	14 May 78
A	12	20	20	23 May 78
A	13	70	70	23 May 78
G	14	30	30	27 May 78
H	15	25	25	27 May 78
G	16	45	45	28 May 78
G	17	130	130	28 May 78
G	18	80	176	27 June 78
G	19	25	55	27 June 78
H	20	15	23	12 June 78

Table 1. (Continued)

Area ID	Colony Number	Maximum Observed Birds (1978)	Adjusted Count (1978)	Date First Discovered
H	21	30	45	12 June 78
H	22	30	45	12 June 78
I	23	50	75	12 June 78
H	24	10	15	12 June 78
B	25	15	34	16 June 78
B	26	100	225	16 June 78
B	27	100	225	23 June 78
K	28	50	150	24 June 78
E	29	30	68	20 June 78
J	30	50	113	20 June 78
L	31	50	113	20 June 78
M	32	40	90	20 June 78
M	33	50	113	20 June 78
M	34	30	68	20 June 78
TOTAL		1,550	2,428	

[a]Colonies 1-10 were intensively studied, colonies 11-28 were visited on the ground, and colonies 23-34 were viewed only during aerial surveys.

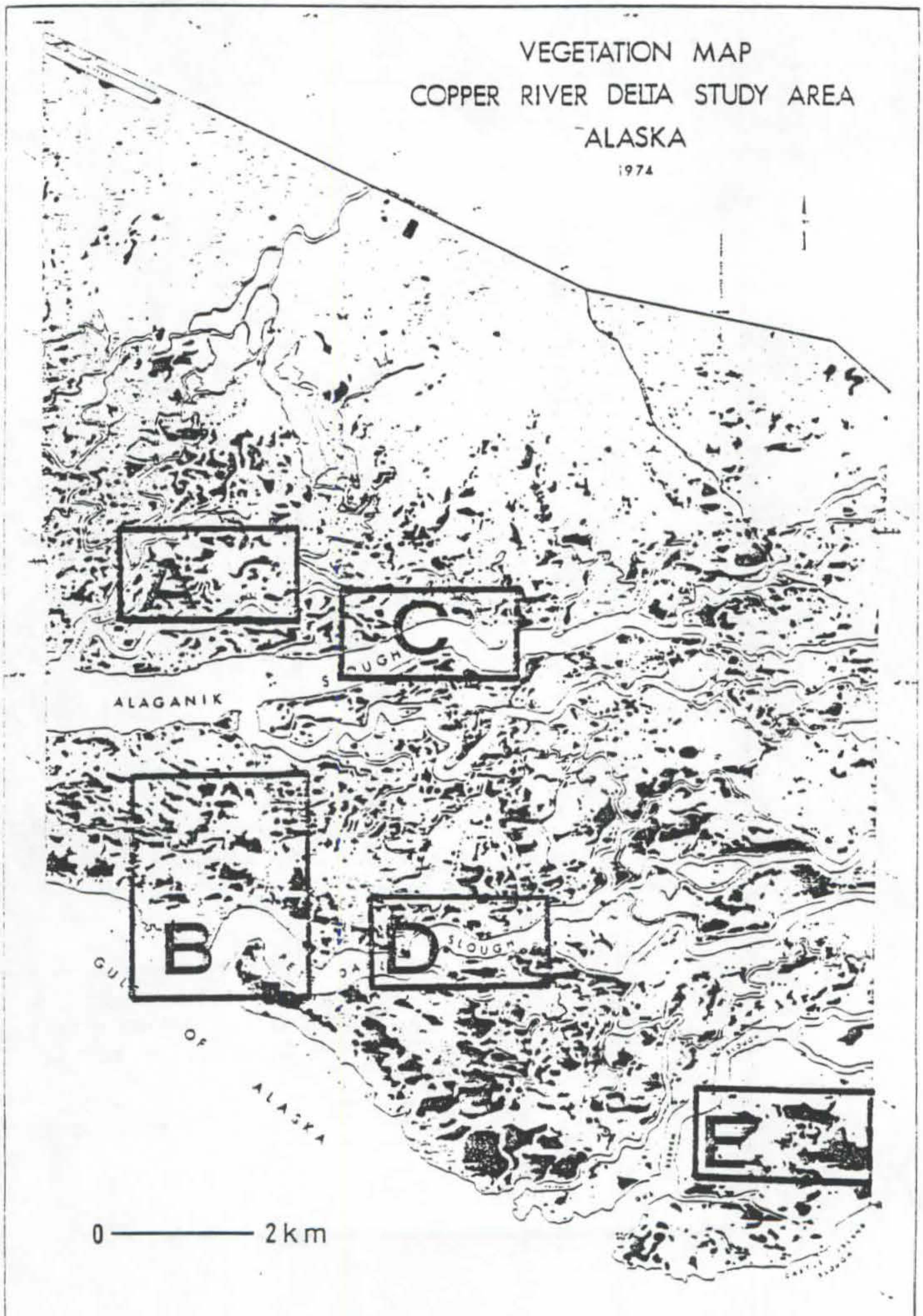


Figure 2. Map of the central portion of the west side of the Copper River Delta showing location areas of Aleutian tern colonies.

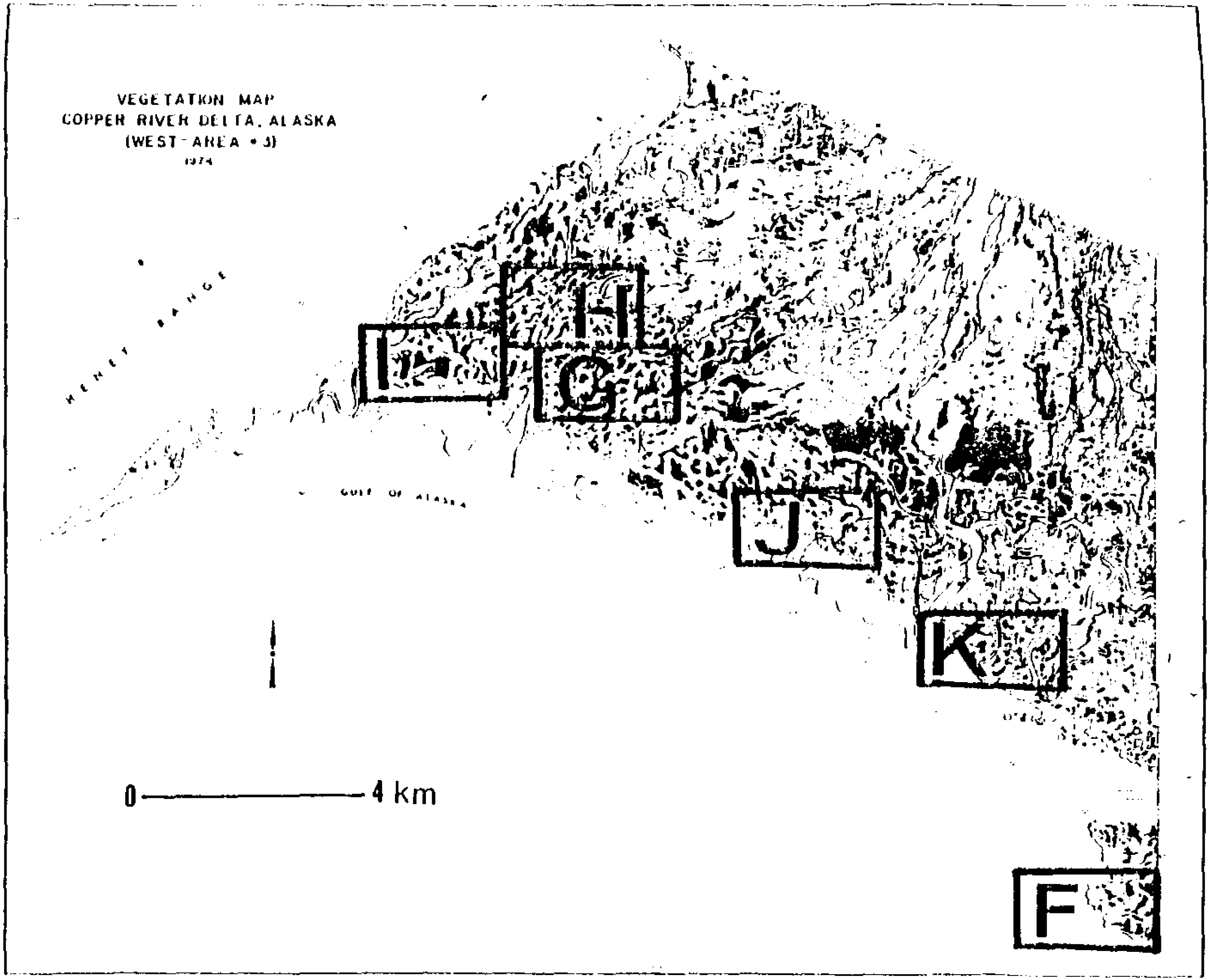


Figure 3. Map of the western portion of the west side of the Copper River Delta showing location areas of Aleutian tern colonies.

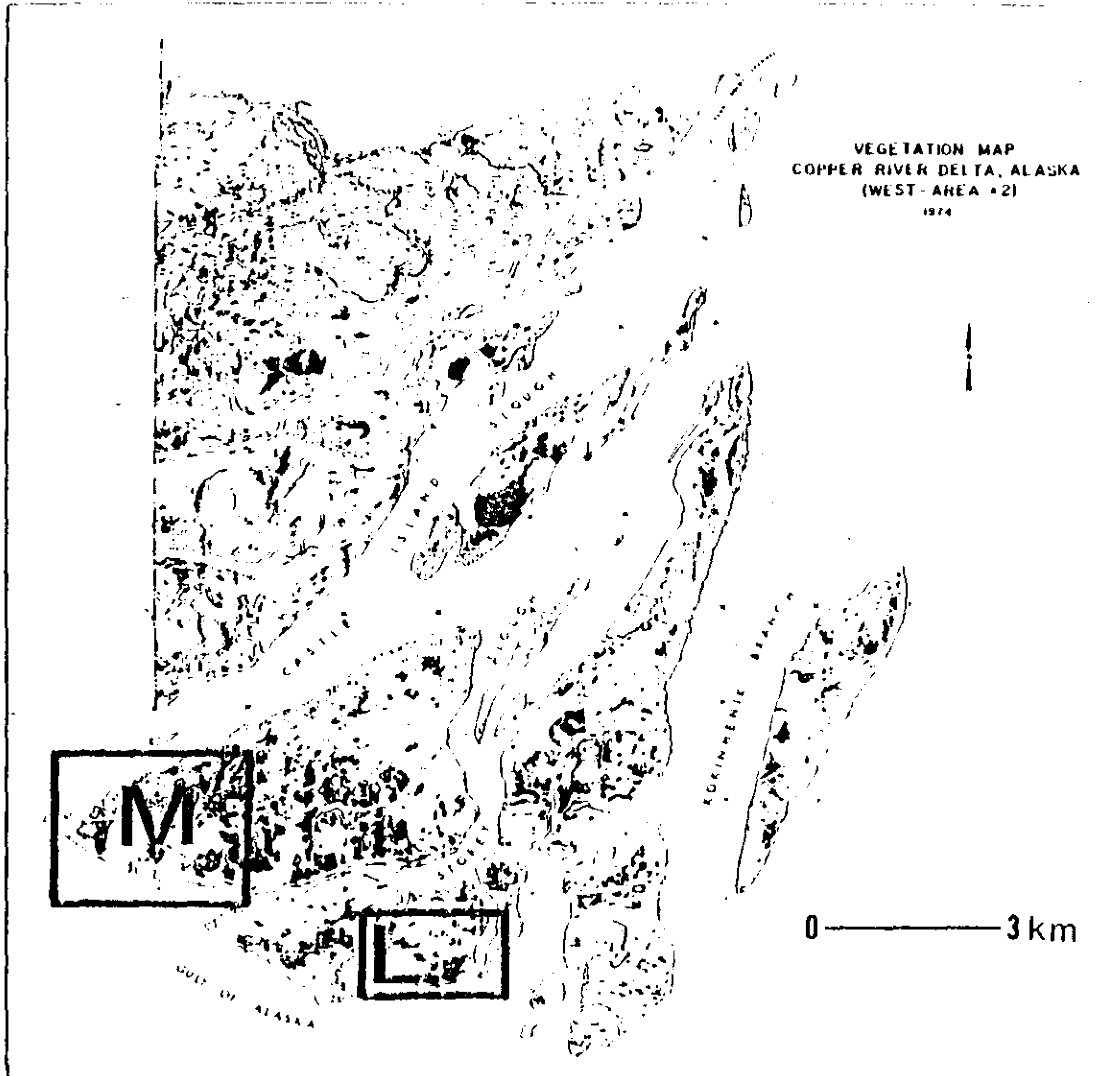


Figure 4. Map of the eastern portion of the west side of the Copper River Delta showing location areas of Aleutian tern colonies.

Table 2. Distance to the tidal mudflat from Aleutian tern colonies visited on the ground on the west side of the Copper River Delta.

Distance to Tidal Mudflat (km)	Number of Colonies	Number of Birds (Observed)	Number of Birds (Adjusted)
0-0.5	6	305	574
0.51-1.0	2	100	225
1.01-1.5			
1.51-2.0	4	195	195
2.01-2.5	6	325	451
2.51-3.0	5	215	235
3.01-3.5	2	100	115
3.51-4.0	1	15	25
4.01-4.5			
4.51-5.0			
5.01-5.5	1	35	35
5.51-6.0	1	10	10
TOTAL	28	1,300	1,863

censused during visits to colonies on the ground and 250 Aleutian terns were counted at the 6 colonies observed only during the aerial survey on 20 June. Adjusting numbers of terns in 17 colonies that were located late in the nesting season (after 11 June 1978) yielded 2,428 breeding adults (Table 1). Because of the difficulty of access to large portions of the delta and the extreme difficulty of identifying Aleutian tern colonies during aerial surveys, I considered this estimate conservative.

1979 Colony Activity

In June of 1979, Aleutian terns were present in all 12 colonies visited (numbers 9, 10, 14-22, 24, Table 1) in the Eyak River area on the western edge of the survey area. Seven (numbers 1, 3, 12, 13, 25, 26, 28, Table 1) of the remaining 15 colony sites visited in the central portion of the survey area were inactive during June of 1979.

Because visits were made to these colonies prior to the fledging of young, the presence or absence of adult Aleutian terns should be a reasonable indicator of the breeding activity at these colonies. However, the absence of birds in June did not preclude the possibility that some colonies were abandoned prior to visitation in 1979.

General Characteristics of Vegetation at Colony Sites

Aleutian tern colonies occurred in two distinctive areas: the Eyak River area on the western edge of the study area, and the central and eastern portion of the study area. Based on criteria derived from Potyondy et al. (1975) and Crow (1968) these two areas represented different stages of successional development. In the Eyak River area,

a region of poorly defined ponds and little development of natural levees, colony sites had characteristics of very early successional development including high soil moisture, low plant species diversity, predominance of plants tolerant of flooding and high soil moisture and low occurrence of shrubs. In the central and eastern portion of the study area, a region of well-developed pond basins and well-developed natural levees, colony sites possessed characteristics of later stages of successional development: moderate soil moisture, relatively high plant species diversity, occurrence of plants intolerant to flooding and presence of moderate amounts of shrubs.

Succession throughout the delta is developing toward a *Tsuga* climax which is the same dominant climax as that of the upland (Crow 1968). However, vegetation in the Eyak River area is in an early successional stage because it was elevated above the influence of tides only after the 1964 earthquake. Before 1964, the central and eastern portions of the study area were affected by tidal flooding less completely and less frequently than the Eyak River area and, therefore, had contained vegetation characteristic of drier sites and later successional development for a longer period of time.

Classification of Vegetation Zones

Vegetation communities of the 10 intensively studied colonies were classified within 10 general vegetation zones (Table 3). *Carex lyngbyaei* was the most widespread and abundant plant species encountered in all colonies and, as such, occupied a prominent position in almost all of the vegetation zones. Based on one of two simple

Table 3. The average moisture index, density index and range of average percent cover by colony for dominant cover types of intensively studied colonies 1-10.

Vegetation Zone	Moisture N	Moisture Index	Density N	Density Index	Dominant Cover	Average Percent Cover
Sedge	248	3.7	227	3.9	graminoids	70-89
					silverweed	0-17
Iris/Sedge/Forb	387	3.2	395	3.5	graminoids	30-73
					iris	9-19
					silverweed	2-17
					moss	3-38
Myrica/Iris	143	3.1	137	3.8	graminoids	23-44
					iris	10-16
					sweetgale	20-33
					moss	5-46
Sedge/Juncus/Grass	62	3	62	2.4	graminoids	33
					rush	7
					moss	10
					bare ground	33
Bare Ground	8	3	8	.5	bare ground	80
					moss	10
Sedge/Cicuta	53	4.7	53	4.3	graminoids	77
					water hemlock	4
Sedge/Lathyrus	31	3.5	31	4.8	graminoids	63-85
					pea	5-23

Table 3. (Continued)

Vegetation Zone	Moisture		Density		Dominant Cover	Average Percent Cover
	N	Index	N	Index		
Willow/Moss	37	3.5	35	2.6	graminoids	34
					willow	8
					moss	49
Sedge/Moss	38	3.1	38	2.4	graminoids	33
					moss	51
Sedge/Prostrate Willow	9	3.2	9	2.2	graminoids	42
					prostrate willow	36

criteria, vegetation was classified into easily recognizable vegetation zones each of which, in most cases, had unique structural characteristics and represented a different level of successional development. The first criterion was the presence of a plant species limited in distribution such as water hemlock (Cicuta spp.), pea (Lathyrus palustris), iris (Iris setosa), sweetgale (Myrica gale), or willow (Salix barclayi) in greater than trace amounts. Most of these species of plants apparently were distributed along a gradient of decreasing soil moisture which was reflected by the moisture index of their respective vegetation zones (Table 3): Sedge/Cicuta, 4.7; Sedge/Lathyrus, 3.5; Iris/Sedge/Forb, 3.2; Myrica/Iris, 3.1, and indicated increasing levels of successional development. The second criteria was a high percent coverage of a common species such as moss or prostrate willow (Salix arctica). Neither of these two species appeared to fit readily into any successional scheme. Wet areas where Carex lyngbyaei occurred as a monospecific stand were classified within the Sedge Zone.

The highest moisture indices, the greatest percent coverages of moisture tolerant sedge, and the densest vegetation were found in the Sedge, Sedge/Cicuta, and Sedge/Lathyrus zones (Table 3). These 3 vegetation zones, characteristic of early seral stages, composed the entire area of intensively studied colonies in the Eyak River area, and were characteristic of most colonies located in the western portion of the survey area.

The greater diversity of vegetation zones found within colonies of the central and eastern portions of the survey area reflected

differences in drainage and soil moisture resulting from variations of local relief, and represented successional stages ranging from marsh to early upland. The sequence of Sedge, Iris/Sedge/Forb and Myrica/Iris zones occurred along gradients of decreasing soil moisture, increasing plant diversity, and increasing amounts of woody vegetation. With the exception of Colony 6 (discussed below), the Iris/Sedge/Forb Zone either singularly or in combination with the Myrica/Iris Zone was characteristic of advanced successional development, and comprised major portions of all Aleutian tern colonies visited in the central and eastern portions of the study area. The Sedge/Juncus/Grass Zone was an exception in this region and was observed in only one colony (Colony 6). This zone occurred as a pioneering finger of vegetation extending out onto the tidal mudflat below the pre-earthquake erosion cutbank.

Selection of Vegetation Zones as Nest Sites

Aleutian terns displayed no selectivity for vegetation zones within colonies as locations for nests. In all 10 intensively studied colonies nests were distributed among vegetation zones in proportion to the area of the zones ($\underline{P}<0.05$).

Nest Site Selection Within Vegetation Zones

In general, vegetative structure at nest sites was not different than vegetative structure at systematically sampled sites within vegetation zones. In 92 of 104 comparisons, percent cover was not significantly different at nest sites than at systematically sampled

sites within vegetation zones ($\underline{P}$<0.05). However, strong selection was present within vegetation zones possessing extreme structural or moisture characteristics.

Aleutian terns tended to select nest sites that provided cover within sparsely vegetated zones, while avoiding heavy cover in moderately vegetated zones. Sweetgale, indicative of advanced succession and the densest of all plant species encountered, was avoided as nest sites. Sweetgale had significantly ($\underline{P}$<0.05) greater percent coverage (28.2%, n=145) in the Myrica/Iris Zone than at nest sites in the same zone (0.5%, n=29).

Within some low density vegetation zones, however, the shift in preference for nest sites was toward dense cover. In the Juncus/Sedge/Grass Zone, bare ground accounted for 33 percent (n=64) of the entire vegetation zone and was significantly greater (t=6.32, d.f.=90) in coverage than at nest sites (0.7%, n=28), and rush (Juncus arcticus) was significantly more abundant (t=2.65, d.f.=90) at nest sites (14.6%, n=28) than generally in the zone (7.0%, n=64). The density index of 3.4 at nest sites was significantly higher (t=4.93, d.f.=88) than the density index of 2.4 in the Juncus/Sedge/Grass Zone. A similar trend was noted within the Iris/Sedge/Forb Zone in one colony in which overall vegetation density was low (2.6, n=25). Graminoids had significantly greater (t=1.99, d.f.=30) coverage at nest sites (42.9%, n=7) than at systematically sampled sites (30.4%, n=25), and percent coverage of moss was significantly less (t=2.87, d.f.=30) at nest sites (17.1%, n=7) than in the vegetation zone (38.4%, n=25).

In the wettest vegetation zones, such as Sedge and Sedge/Cicuta, average moisture indices were significantly lower at nest sites ($\underline{P}<0.05$) than in the vegetation zone (5 of 8 comparisons). This difference occurred because terns selected sedge hummocks and other raised areas as nest sites in these wet zones. Sedge tended to be tall but sparse in these wet zones and the selection of sedge hummocks as nest sites resulted in significantly greater coverage of sedge at nest sites than in the systematic vegetation sites of the zone.

Nest Density

Density of nests in the 10 colonies averaged 84.3/ha ($0.0084/m^2$), and ranged from 36.9 to 151.3 nests/ha (Table 4). This density was considerably lower than the nesting density of some other species of terns: royal terns (*Thalasseus maxima*), 7.5 nests/m^2; sandwich terns (*T. sandvicensis*), 2.1 nests/m^2; roseate terns (*Sterna dougallii*), 0.4 nests/m^2; common terns (*S. hirundo*), 0.06-0.13 nests/m^2; and arctic terns (*S. paradisaea*), 0.02 nests/m^2 (Langham 1974, Buckley and Buckley 1977). As a broad generalization, physically large colonies had more nests, lower densities, and longer average nearest neighbor distances than colonies small in area (Table 4). No obvious relationship was apparent between the density of nests and the percent coverage of life form classes (moss, forbs, iris and rush, graminoids, and shrubs) of the vegetation of colonies.

Colony 6 which had the greatest density of all colonies was an exception, but not without unique characteristics. The residual cover of rush and grass that was available at the time of nest initiation in

Table 4. The density and average nearest neighbor distance of Aleutian tern nests in intensively studied colonies 1-10.

Colony Location Number	Colony Area (m^2)	Number of Nests	Density (Nests/ha)	Average Nearest Neighbor Distance (m)
1	7318	27	36.9	9.09
2	7363	32	43.5	8.50
3	4525	24	52.9	7.13
4	1672	19	113.6	4.70
5	2213	17	76.9	3.22
6	1855	28	151.5	4.12
7	1587	17	107.5	5.02
8	1912	20	104.2	4.07
9	1801	14	77.5	5.77
10	2460	20	81.3	6.20

Colony 6 may have created a visual barrier that permitted high nest density. Also, the restricting barrier of a 2 meter high tidal cut-bank on one side, and unvegetated tidal mudflat on the other 3 sides prohibited expansion of colony area despite possible increases in population numbers. Restricting boundaries and fringes of unsuitable nesting habitat such as ponds, sloughs and dense shrubs may be an important force in restraining the areal growth of a colony.

Dispersion of Nests

The dispersion of nests within colonies and within vegetation zones was largely random. In only 1 of the 10 colonies was dispersion of nests significantly different from random ($\underline{P}<0.05$). In the one exception (Colony 5), nests had an aggregate dispersion. Within vegetation zones, nest dispersion departed significantly ($\underline{P}<0.05$) from random in 4 of 20 cases; in 2 cases nest dispersion was aggregated and in 2 cases nest dispersion was uniform.

Nest Success

Nest success was uniformly high (80.5%) in 6 of 7 colonies (Table 5). The one exception was Colony 7 in which only 56% of the nests hatched. This colony was located 5.4 km from the mudflat border in an area with a high incidence of shrubby vegetation. The inland location, shrubby vegetation and low nest success suggested that the colony was in an unfavorable location. One other colony (Colony 11, not intensively studied) in a shrubby, inland location, also was small (3 nests) and had low nest success (1 egg possibly hatched).

Table 5. The hatching success, average number of chicks hatched per nest and the number of dead chicks found at nest bowls per 100 nests for intensively studied Aleutian tern colonies 1-7.

Colony Location Number	Total Nests	Fate of Nests (%)				Hatched Chicks per Nest	Dead Chicks per 100 Nests
		Destroyed	Abandoned	Hatched	Unknown		
1	28	10.7	3.6	85.7	0	1.39	21.4
2	32	12.5	0	75.0	12.5	1.16	28.1
3	25	4.0	12.0	84.0	0	1.28	24.0
4	20	10.0	10.0	70.0	10.0	1.05	15.0
5	15	0	6.7	86.7	6.7	1.27	26.7
6	29	10.3	6.9	82.8	0	1.28	20.7
7	16	18.8	18.8	56.3	6.2	0.88	12.5
TOTAL	165	9.7	7.3	78.2	4.8	1.21	21.8

Disturbances caused by the investigators apparently did not increase the number of dead chicks that were found at nest bowls. Colonies 9 and 10 which were visited after the initiation of laying and again after hatching was completed had 42 and 55 dead chicks per 100 nests, respectively, and colonies 1-7 which were visited frequently had an average of 21 dead chicks per 100 nests (Table 5).

DISCUSSION

Many more birds (2428) and colonies (34) were located than anticipated at the initiation of this study. Past observations of Aleutian terns suggested a population of perhaps a few hundred nesting Aleutian terns on the Copper River Delta. I was unable to determine definitely if the Aleutian tern population had increased dramatically recently or if past observations grossly underestimated their numbers. Arctic terns were common on the Copper River Delta and differed in appearance from Aleutian terns in only subtle ways. Access to and travel about the delta were difficult, and Aleutian terns were present on the delta for only a short period of time (late April to late July) during the spring and summer. Thus, earlier observers may not have frequented colony locations, may have easily overlooked Aleutian terns or misidentified them as arctic terns. I think it most likely that Aleutian terns nested on the Copper River Delta at least in the recent past but that their numbers increased substantially in the past 5-10 years.

In respect to the large area comprising the west side of the Copper River Delta, Aleutian terns showed considerable selectivity in choosing locations for colony sites. Colony locations were restricted to a narrow vegetated strip paralleling the tidal mudflat with 82% of the colonies within 3 km of the mudflat. Although the size of colonies or number of birds was not significantly correlated to the distance of colonies from the tidal mudflat within this strip, increased amounts of dense shrubs appeared to be an important factor in inhibiting the selection of more inland locations. Within colony sites Aleutian terns showed no selection for vegetation zones and only moderate selection in

choosing a nest site within vegetation zones. Selection at the nest site level became apparent only in extreme conditions such as a preference for higher density cover in a very low density vegetation, preference for low density cover in a high density vegetation, avoidance of bare ground, or the avoidance of late successional species (sweetgale). However, I felt that Aleutian terns were selective in their habitat preferences, but that the selection was at the level of colony location rather than at the level of nest site location.

I think that colonies in the Eyak River area were only recently established while those in the central and eastern portion of the delta may have been present prior to the 1964 earthquake. According to reports from local residents, the Eyak River area was regularly flooded by spring tides prior to 1964. Such regular flooding would have prevented nesting by Aleutian terns. Following the uplift resulting from the 1964 earthquake not even the highest storm tides flooded the uplands of the Eyak River area. However, the area was quite flat and poorly drained, and consequently was subject to shallow flooding from the heavy precipitation characteristic of the Copper River Delta. Terns avoided this shallow flooding by placement of nests on hummocks of sedge. These hummocks were composed of accumulated sedge and other organic matter and probably were not of sufficient size and abundance for nesting terns until at least several years after the 1964 earthquake. Thus, colonies in the Eyak River area were a maximum of 14 years old and probably from 5-10 years old.

Colonies in the central and eastern portion of the study area were in sites that were probably suitable for nesting terns prior to the

1964 earthquake. Based on pre-1964 conditions, Potyondy et al. (1975) divided the central portion of the delta into 3 zones according to frequency of tidal flooding: not flooded (inland portion of dense shrubs and trees), less frequently flooded, and frequently flooded (Figure 5). The less frequently flooded areas comprised less than 40% of the portion of the delta flooded with any frequency by tides prior to 1964 but contained 11 of the 12 colonies present in 1978 in that part of the delta mapped by Potyondy et al. (1975). After 1964 none of this part of the delta was flooded even by the severest storm tides. Thus, colonies in the central and eastern portion of my study area appeared to be distributed in relation to conditions existing prior to the 1964 earthquake and I surmised that most were probably present prior to 1964. Flooding of nests was also considered an important factor in the selection of nest sites by geese (Branta canadensis occidentalis) on the Copper River Delta prior to 1964 (Hanson 1961, Shepherd 1965, 1966, Trainer 1959).

The most noticeable gross vegetative change resulting from the uplift of the 1964 earthquake was the invasion and/or expansion of shrubby vegetation onto the outer portions of the delta. Aleutian terns avoided nesting in close proximity to shrubs, and the increasing prevalence of shrubs in the central and eastern portion of my study area may have caused desertion of some of these long established colony sites. The two colonies within areas of the highest shrub cover, and also in the most inland locations, were very small (16 and 3 nests) and those nests had high rates of failure (38 and 67 percent, respectively). Previous investigators predicted that mammalian predation of

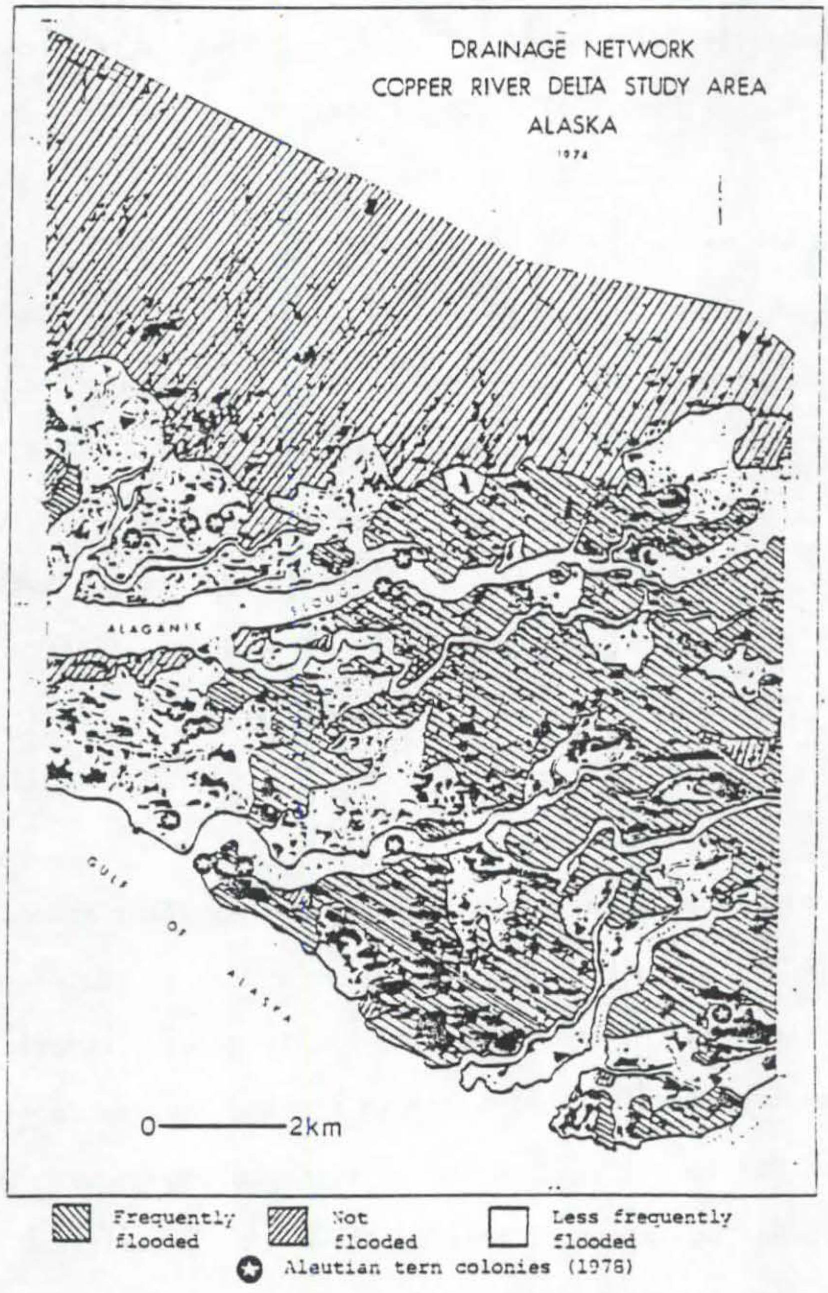


Figure 5. Map showing the pre-earthquake areas of the Copper River Delta and the frequency with which they were covered by tidal flooding with the locations of current Aleutian tern colonies superimposed (adapted from Potyondy et al. 1975).

goose nests would increase as abundance of shrubs increased on the Copper River Delta (Shepherd 1965, 1966, Trainer 1967). The high proportion of inactive colonies in 1979 (7 of 15) that had been active in 1978 was further evidence that the central and eastern portion of the study area may be becoming increasingly unfavorable for nesting terns.

The high concentration of birds and colonies in the Eyak River area and the degradation and desertion of colonies in the central and eastern portion of the study area indicated that a shift in the distribution of Aleutian tern colonies had occurred. The characteristics of the vegetation in the Eyak River area in 1978 were probably similar to characteristics that were present in the central and eastern region prior to the 1964 earthquake.

The apparent lack of selectivity of nest sites may be due to the selection of colony sites with an abundance of suitable nest sites and to the strong colony site tenacity characteristic of terns. Some species of terns remain faithful to nest and colony sites despite degradation of the habitat (Austin 1949). On the Copper River Delta the changes in vegetative communities initiated by the 1964 earthquake may have resulted in some colonies and nest sites being located in places much different in 1978 than when nests and colonies were originally selected. However, the random placement of nests within colonies suggested that neither the environment nor the social structure of the terns strongly influenced selection of nest sites within colonies.

Although some species of terns display strong tenacity to colony sites, abandonment of colonies does occur when disturbance and/or degradation of the habitat become excessive (Hawksley 1957). In such cases, the entire group of birds moves and selects a new colony site as a group (Austin 1951, McNicholl 1975). This trait facilitates establishment of new colonies by providing a socially intact cadre of experienced breeders of sufficient number to form a viable colony. Such a trait, if possessed by Aleutian terns, would be advantageous on the Copper River Delta because of the unpredictable variability of the environment produced by tectonic uplift, subsidence and the attendant successional changes.

LITERATURE CITED

Austin, O.L. 1940. Some aspects of individual distribution in the Cape Cod tern colonies. Bird-Banding 11(3):155-169.

__________. 1946. The status of the Cape Cod terns in 1944. Bird-Banding 17(1):10-27.

__________. 1947. A study of the mating of the common tern. Bird-Banding 18(1):1-16.

__________. 1949. Site tenacity, a behavior trait of the common tern. Bird-Banding 20(1):1-39.

__________. 1951. Group adherence in the common tern. Bird-Banding 22(1):1-15.

Bent, A.C. 1921. Life histories of North American gulls and terns, Order Longipennes. U.S. Natl. Mus. Bull. 113:265-269.

Bromley, R.G.H. 1976. Nesting and habitat studies of the dusky Canada goose on the Copper River Delta, Alaska. M.S. thesis, Univ. of Alaska, Fairbanks. 81 p.

Buckley, P.A. and F.G. Buckley. 1977. Hexagonal packing of royal tern nests. Auk 94:36-43.

Clark, P.J. and F.C. Evans. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. Ecology 35(4): 445-453.

Coulson, J.C. and J. Horobin. 1975. The influence of age on the breeding biology and survival of the arctic tern. J. Zool. 178:247-260.

Crow, J.H. 1968. Plant ecology of the Copper River Delta, Alaska. Ph.D. thesis, Washington State Univ., Pullman. 120 p.

__________. 1972. Earthquake-initiated changes in the nesting habitat of the dusky Canada goose. In the Great Alaska Earthquake of 1964: Biology. Nat'l. Acad. of Sci. Publ. 1604. Washington, D.C. pp. 130-136.

Crowell, E.M. and S. Crowell. 1946. The displacement of terns by herring gulls at the Weepecket Islands. Bird-Banding 17(1):1-10.

Cullen, J.M. 1960. Some adaptations in the nesting behavior of terns. Int. Orn. Cong. 12(1):153-157.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northw. Sci. 33:43-64.

Dement'ev, G.P., N.A. Gladkov, eds. 1951. Birds of the Soviet Union. vol. III, translation 756 p.

Friedmann, H. 1933. Notes on some birds of Goodnews Bay, Alaska. Condor 35(4):239-240.

Gabrielson, I.N. and F.C. Lincoln. 1959. The Birds of Alaska. Wildl. Mgt. Inst. Washington, D.C. 922 p.

Hansen, H.A. 1961. Loss of waterfowl production to tide floods. J. Wildl. Manage. 25(3):242-248.

Hatch, J.J. 1970. Predation and piracy by gulls at a ternery in Maine. Auk 87:244-254.

Hawksley, O. 1957. Ecology of a breeding population of arctic terns. Bird-Banding 28(2):57-97.

Hersey, F.S. 1920. The probable breeding of the Aleutian tern in southeastern Alaska. Condor 22(6):203-204.

Howell, J.C. 1948. Observations on certain birds of the region of Kodiak, Alaska. Auk 65:352-358.

Hulten, E. 1968. Flora of Alaska and neighboring territories. Stanford Univ. Press, Stanford. 1008 p.

Isleib, M.E. and B. Kessel. 1973. Birds of the North Gulf Coast-Prince William Sound region, Alaska, Univ. Alaska Biol. pap. 14. 149 p.

Langham, N.P.E. 1972. Chick survival in terns with particular reference to the common tern. J. Anim. Ecol. 41(2):385-395.

__________. 1974. Comparative breeding biology of the sandwich tern. Auk 91:255-277.

McNicholl, M.K. 1973. Habituation of aggressive responses to avian predators by terns. Auk 90:902-903.

__________. 1975. Larid site tenacity and group aherence in relation to habitat. Auk 92:98-104.

Murie, O.J. 1936-38. Fauna of the Aleutian Islands and Alaska Peninsula. North American Fauna 61:1-364.

Nelson, E.W. 1887. Report upon natural history collections made in Alaska between the years 1877 and 1881. Arctic Ser. Pub. No. 3, issued in connection with the Signal Service, U.S. Army, Washington, D.C., pp. 19-226.

Nisbet, I.C.T. and W.H. Drury. 1972. Measuring breeding success in common and roseate terns. Bird-Banding 43(2):97-106.

Nisbet, I.C.T. and M.E. Cohen. 1975. Asynchronous hatching in common and roseate terns. Ibis 117:374-379.

Olsen, S.T. 1964. Reconnaissance of Copper River Delta following the March 27, 1964, earthquake. Admin. Rept. U.S.D.A. For. Serv., R-10, Juneau. 7 p.

Potyondy, J.P., M.P. Meyer, and A.C. Mace, Jr. 1975. Hydrologic response of the Copper River Delta-Controller Bay area, Alaska to land emergence and uplift. U.S.D.A. Contract 08-DNN-74. Univ. of Minnesota, St. Paul. 81 p.

Reimnitz, E. 1972. Effects in the Copper River Delta. In The Great Alaska Earthquake of 1964. Oceanography and Coastal Engineering. Nat'l. Acad. Sci. Publ. 1604. Washington, D.C. pp. 290-302.

Scheierl, R. and M. Meyer. 1977. Habitat analysis of the Copper River Delta game management area, Alaska. Res. Rept. 77-8, Remote Sensing Lab., Coll. of Agric., For. and Home Econ., Univ. Minn., St. Paul. 73 p.

Shepherd, P.E.K. 1965. A preliminary evaluation of earthquake damage to waterfowl habitat in southcentral Alaska. 45th Ann. Conf. West. Assoc. State Game and Fish Comm. 9 p.

__________. 1966. Current status of the Copper River Delta waterfowl habitat and the dusky Canada goose nesting population. Paper presented to the Northwest Section meeting of T.W.S. at LaGrande, Oregon. 25 March. 9 p.

Trainer, C.E. 1959. The 1959 western Canada goose (Branta canadensis occidentalis) study of the Copper River Delta, Alaska. 9 p. In Annual Waterfowl Report, Alaska. U.S. Fish and Wildlife Serv., Alaska.

__________. 1967. Appraisal of Canada goose nesting densities on the Copper River Delta, Alaska. Unpubl. manuscript. 9 p.

Walker, E.P. 1923. Definite breeding record for the Aleutian tern in southern Alaska. Condor 25(4):113-117.

APPENDICES

Appendix I. The area (m^2) of vegetation zones within intensively studied colonies 1-10. The area of each vegetation zone is given over the percent (%) it represents within the total colony area.

	Vegetation Zone Area				
Vegetation Zone	Colony 1 m^2 / %	Colony 2 m^2 / %	Colony 3 m^2 / %	Colony 4 m^2 / %	Colony 5 m^2 / %
Sedge	3267 44.6	2007 27.3	300 6.6	345 20.6	1582 71.5
Iris/Sedge/Forb	3407 46.6	2897 39.4	2339 51.7	1327 79.4	631 28.5
Myrica/Iris		2459 33.4	1886 41.7		
Sedge/Moss	644 8.3				
Total Area	7318	7363	4525	1672	2213
Vegetation Zone	Colony 6 m^2 / %	Colony 7 m^2 / %	Colony 8 m^2 / %	Colony 9 m^2 / %	Colony 10 m^2 / %
Sedge		653 41.1			1750 71.1
Iris/Sedge/Forb		934 58.9	655 34.3		
Myrica/Iris			119 6.2		
Willow/Moss			929 48.6		
Sedge/Lathyrus				397 22.0	710 28.9
Sedge/Cicuta				1404 78.0	
Sedge/Pros. Willow			209 10.9		
Sedge/Juncus/Grass	1647 88.8				
Bare Ground	208 11.2				
Total Area	1855	1587	1912	1801	2460

Appendix II. The distribution of Aleutian tern nests by vegetation zone for intensively studied colonies 1-10. The number of nests per zone in each colony is given over the percent this number represents of total nests within the colony.

	Nest Distribution by Vegetation Zone				
Vegetation Zone	Colony 1 nests/%	Colony 2 nests/%	Colony 3 nests/%	Colony 4 nests/%	Colony 5 nests/%
Sedge	11 40.7	11 34.4	1 4.2	3 15.8	13 76.5
Iris/Sedge/Forb	16 59.3	7 21.9	8 33.3	16 84.2	4 23.5
Myrica/Iris		14 43.8	15 62.5		
Total	27	32	24	19	17

Vegetation Zone	Colony 6 nests/%	Colony 7 nests/%	Colony 8 nests/%	Colony 9 nests/%	Colony 10 nests/%
Sedge		4 23.5			20 100.0
Iris/Sedge/Forb		13 76.5	7 35.0		
Willow/Moss			11 55.0		
Sedge/Lathyrus				2 14.3	
Sedge/Cicuta				12 85.7	
Sedge/Pros. Willow			2 10.0		
Sedge/Juncus/Grass	28 100.0				
Total	28	17	20	14	20

Appendix III. Density index values from systematically sampled vegetation zones and from nest sites for intensively studied colonies 1-10 with the sample size in parentheses.

	Density Index				
	Colony 1	Colony 2	Colony 3	Colony 4	Colony 5
Vegetation Zone	zone/nest	zone/nest	zone/nest	zone/nest	zone/nest
Sedge	3.6(97) / 3.6(11)	4.1(63) / 4.1(11)	4.2(17) / 4.0(1)	3.6(15) / 3.6(3)	4.0(14) / 3.6(12)
Iris/Sedge/Forb	3.4(99) / 3.4(13)	3.3(105) / 3.4(7)	3.6(83) / 3.5(8)	3.3(48) / 3.5(16)	3.8(6) / 3.5(4)
Myrica/Iris		3.7(75) / 3.6(14)	4.0(62) / 3.3(14)		
Sedge/Moss	2.4(38) / -				

	Colony 6	Colony 7	Colony 8	Colony 9	Colony 10
Vegetation Zone	zone/nest	zone/nest	zone/nest	zone/nest	zone/nest
Sedge		4.2(21) / 3.8(4)			4.1(66) / 4.3(19)
Iris/Sedge/Forb		3.9(34) / 3.8(12)	2.6(25) / 2.9(7)		
Myrica/Iris			2.7(6) / -		
Willow/Moss			2.6(35) / 2.3(10)		
Sedge/Lathyrus				4.5(14) / 5.0(2)	5.0(17) / -
Sedge/Cicuta				4.3(53) / 4.7(12)	
Sedge/Juncus/Grass	2.4(62) / 3.4(28)				
Sedge/Pros. Willow			2.2(9) / -		
Bare Ground	0.5(3) / -				

Appendix IV. Moisture index values from systematically sampled vegetation zones and from nest sites for intensively studied colonies 1-10 with the sample size in parentheses.

	Moisture Index				
	Colony 1	Colony 2	Colony 3	Colony 4	Colony 5
Vegetation Zone	zone/nest	zone/nest	zone/nest	zone/nest	zone/nest
Sedge	4.0(106) 3.5(11)	3.9(63) 3.3(11)	4.0(17) 3.0(1)	3.6(15) 3.3(3)	3.6(14) 3.0(13)
Iris/Sedge/Forb	3.0(107) 3.0(16)	3.4(105) 3.1(7)	3.2(65) 3.0(8)	3.4(48) 3.2(16)	3.0(6) 3.0(4)
Myrica/Iris		3.0(75) 3.0(14)	3.1(68) 3.0(14)		
Sedge/Moss	3.1(38) -				

	Colony 6	Colony 7	Colony 8	Colony 9	Colony 10
Vegetation Zone	zone/nest	zone/nest	zone/nest	zone/nest	zone/nest
Sedge		4.1(21) 3.0(4)			4.3(66) 4.3(20)
Iris/Sedge/Forb		3.1(36) 3.0(12)	3.3(25) 3.1(7)		
Myrica/Iris			3.2(6) -		
Willow/Moss			3.5(37) 3.0(10)		
Sedge/Lathyrus				3.3(14) 3.5(2)	3.2(17) -
Sedge/Cicuta				4.7(53) 4.1(12)	
Sedge/Juncus/Grass	3.0(62) 3.0(28)				
Sedge/Pros. Willow			3.9(2) -		
Bare Ground	3.0(8)				

Appendix V. The average percent coverage of dominant species and cover types from systematically sampled vegetation zones and from nest sites for intensively studied colonies 1-10 with the sample size in parentheses.

	Colony 1 Vegetation Zones					
	Sedge		Iris/Sedge/Forb		Sedge/Moss	
Species or Cover	zone	nest	zone	nest	zone	nest
(n)	(105)	(11)	(112)	(16)	(38)	(0)
Graminoids	78.2	75.5	48.0	51.3	33.3	-
Iris			19.2	17.2		
Silverweed	4.4	4.5	8.7	10.0	3.8	-
Moss	5.4	8.6	15.5	3.8	51.2	-
Dead Vegetation	10.4	9.1	4.4	6.3	5.4	-
Prostrate Willow	-	3.2			1.0	-
Plantago			2.5	3.1		
Shooting Star			0.9	-		

Appendix V. (Cont.)

Species or Cover	Colony 2 Vegetation Zones					
	Sedge zone/nest		Iris/Sedge/Forb zone/nest		Myrica/Iris zone/nest	
(n)	(65)	(11)	(106)	(7)	(77)	(14)
Graminoids	88.0	82.7	68.9	72.1	43.6	60.4
Iris			11.3	5.0	14.4	17.9
Silverweed	9.7	16.4	11.5	13.6	9.6	9.6
Moss			3.9	4.3	5.4	2.9
Sweetgale					24.0	-
Prostrate Willow			3.0	2.1	2.3	2.9

Appendix V. (Cont.)

Species or Cover	Sedge zone	Sedge nest	Iris/Sedge/Forb zone	Iris/Sedge/Forb nest	Myrica/Iris zone	Myrica/Iris nest
	Colony 3 Vegetation Zones					
(n)	(17)	(1)	(38)	(8)	(68)	(15)
	Percent		Percent		Percent	
Graminoids	38.5	95.0	56.0	57.5	22.8	39.3
Iris			17.2	20.6	16.4	20.7
Silverweed	11.5	5.0	14.7	13.8	6.7	8.3
Moss			6.0	6.9	9.2	12.3
Sweetgale					32.0	1.0
Prostrate Willow			2.6	2.5	5.1	7.3
Plantago			3.0	-	3.7	8.3

Appendix V. (Cont.)

Species or Cover	Colony 4 Vegetation Zones: Sedge zone	Sedge nest	Iris/Sedge/Forb zone	Iris/Sedge/Forb nest	Colony 5 Vegetation Zones: Sedge zone	Sedge nest	Iris/Sedge/Forb zone	Iris/Sedge/Forb nest
(n)	(15)	(3)	(51)	(16)	(14)	(13)	(6)	(4)
	Percent		Percent		Percent		Percent	
Graminoids	76.3	73.3	64.1	68.1	79.3	71.5	72.5	72.5
Iris			10.0	8.4			9.2	2.5
Silverweed	6.0	8.3	4.4	7.2	16.3	16.9	16.7	20.0
Moss	6.7	5.0	14.8	10.9	2.1	7.3	3.3	-
Dead Vegetation	11.3	15.0	6.5	5.0				
Prostrate Willow					0.7	3.1	-	5.0

Appendix V. (Cont.)

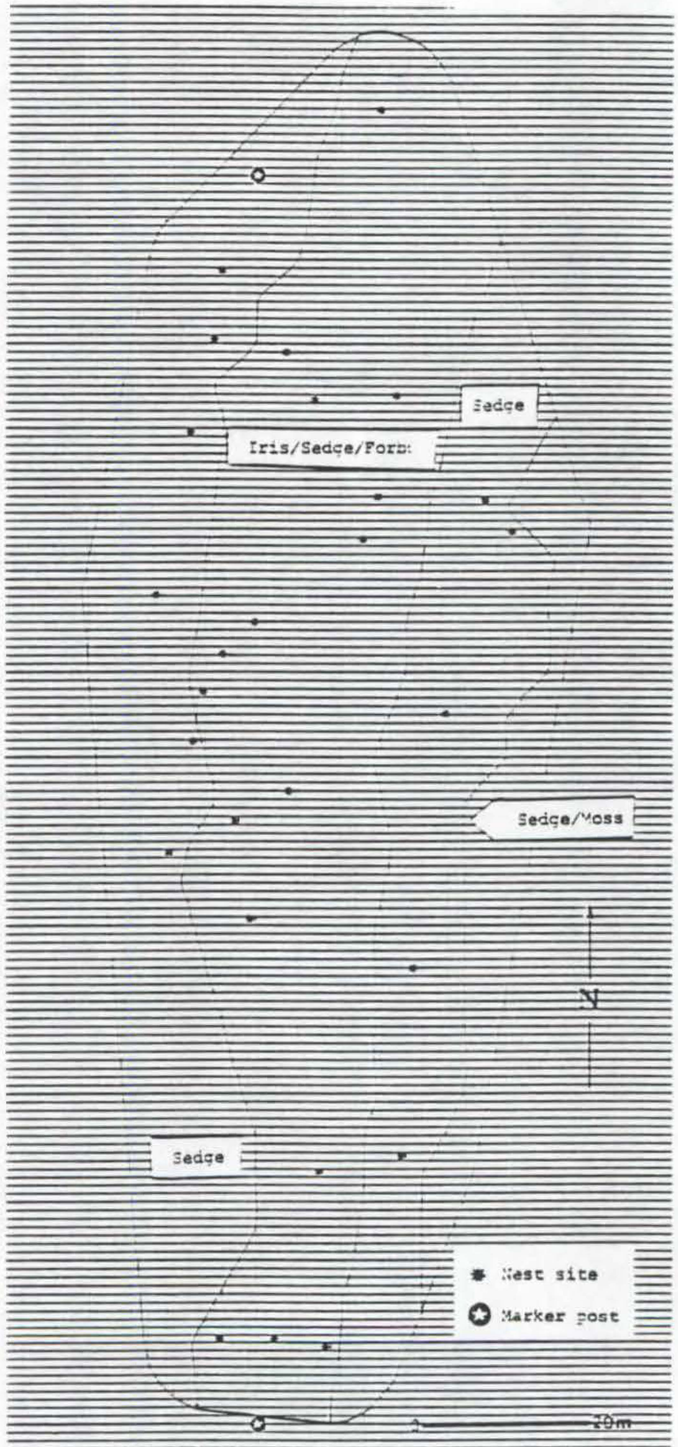
Species or Cover	Colony 6 Vegetation Zones				Colony 7 Vegetation Zones			
	Sedge/Juncus/Grass zone/nest		Bare Ground zone/nest		Iris/Sedge/Forb zone/nest		Sedge zone/nest	
(n)	(64)	(28)	(8)	(0)	(28)	(12)	(21)	(4)
	Percent		Percent		Percent		Percent	
Graminoids	34.2	32.7	5.6	-	68.0	60.0	78.3	62.5
Rush	7.0	14.6	1.3	-				
Iris					13.0	15.0		
Silverweed	8.0	20.1	2.5	-	1.4	3.3	4.5	6.3
Moss	10.2	8.6	10.0	-	7.1	10.4	3.1	2.3
Bare Ground	33.3	0.7	60.0	-				
Dead Vegetation	6.6	10.2			8.8	9.2	14.0	6.3
Prostrate Willow	-	1.3						
Parnassia	-	3.0						

Appendix V. (Cont.).

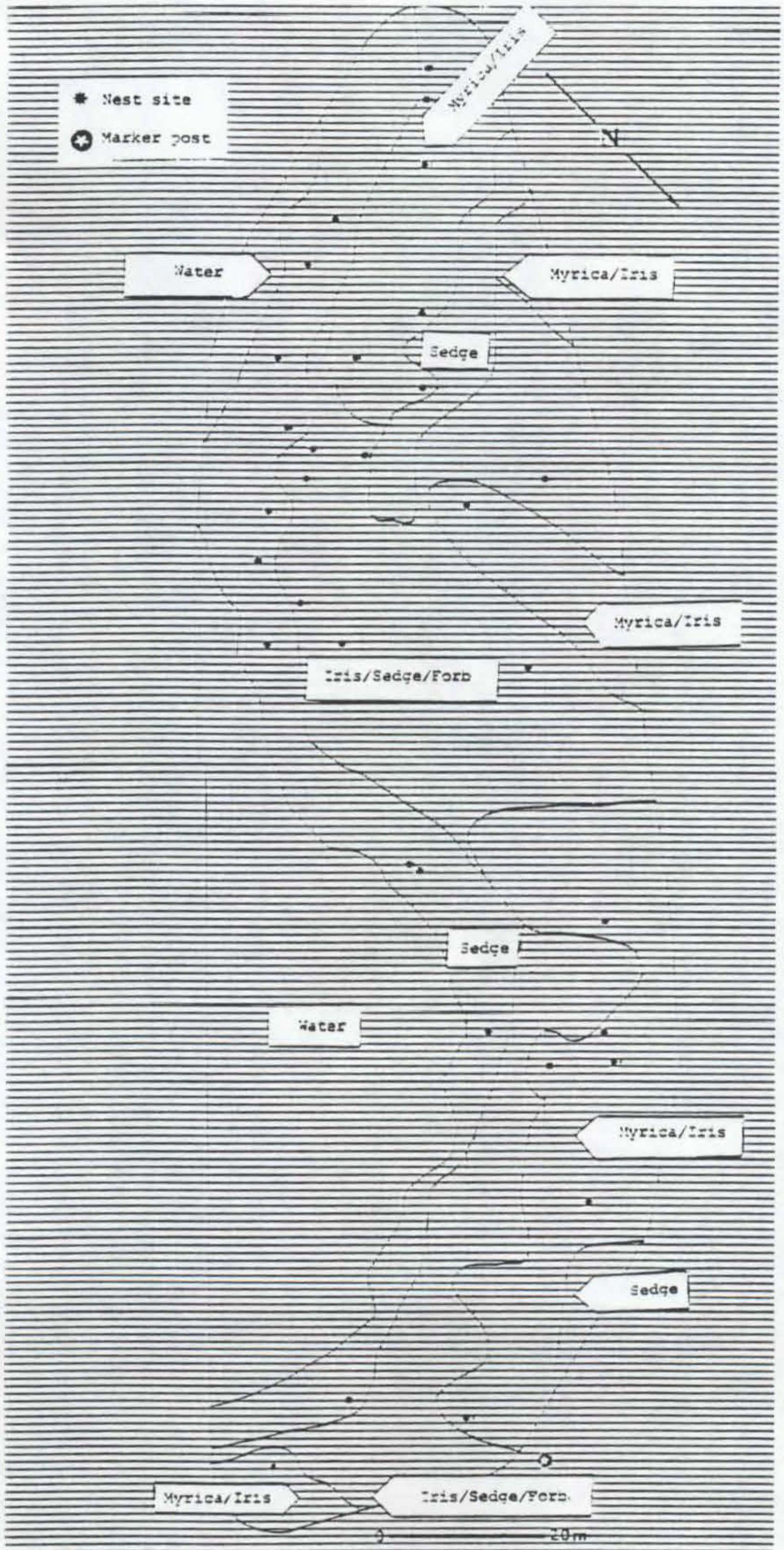
Species or Cover	Colony 8 Vegetation Zones: Iris/Sedge/Forb zone	Iris/Sedge/Forb nest	Willow/Moss zone	Willow/Moss nest	Sedge/Prostrate Willow zone	Sedge/Prostrate Willow nest	Myrica/Iris zone	Myrica/Iris nest
(n)	(25)	(7)	(37)	(11)	(9)	(2)	(6)	(0)
	Percent		Percent		Percent		Percent	
Graminoids	30.4	42.9	34.1	35.9	42.2	42.5	16.7	-
Iris	9.0	17.1	0.7	0.0	-	2.5	10.0	-
Silverweed	6.2	10.7	4.1	4.1			3.3	-
Moss	38.4	17.1	49.2	55.5	18.9	20.0	45.3	-
Sweetgale							20.0	-
Prostrate Willow	14.0	13.6	7.7	4.1	35.6	35.0	5.0	-
Dead Vegetation			3.9	-				
Willow			7.6	3.2				

Appendix V. (Cont.)

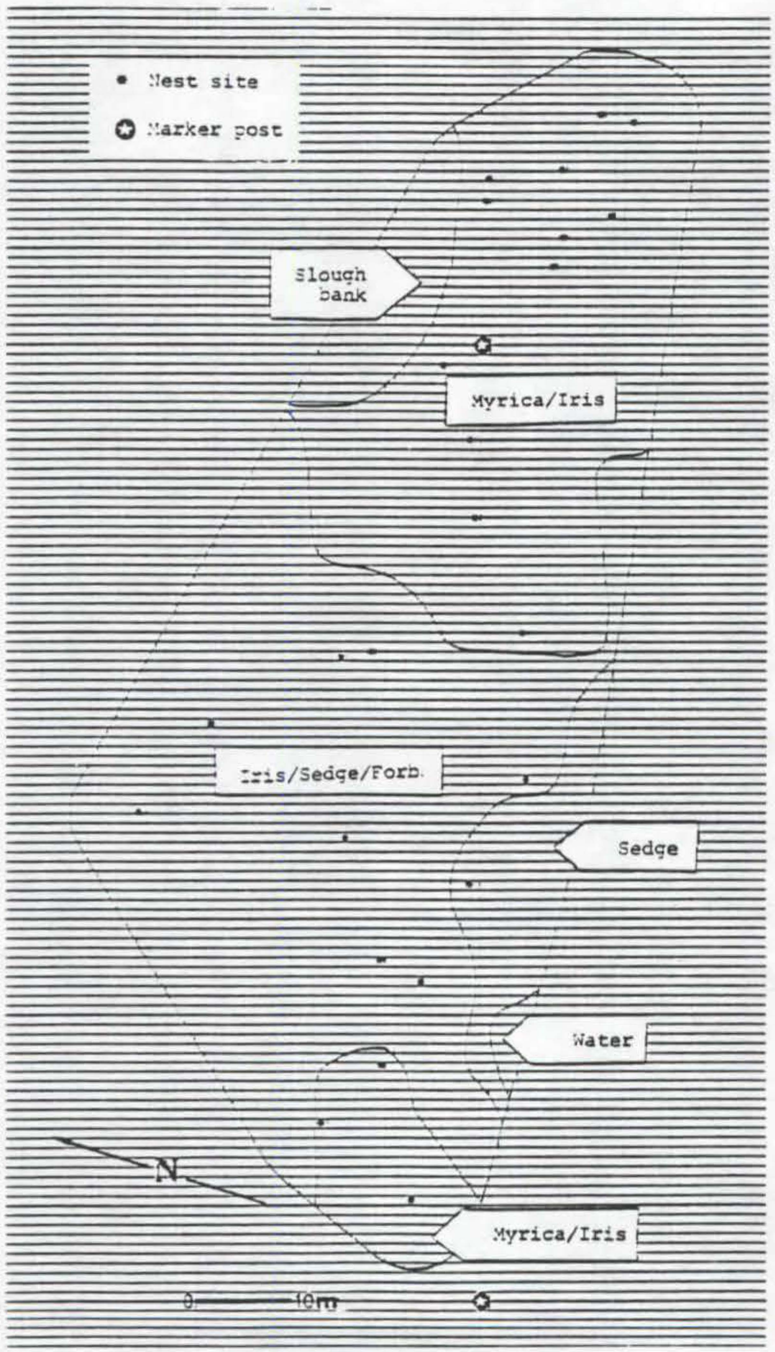
Species or Cover	Colony 9 Vegetation Zones: Sedge/Cicuta zone	nest	Sedge/Lathyrus zone	nest	Colony 10 Vegetation Zones: Sedge zone	nest	Sedge/Lathyrus zone	nest
(n)	(55)	(12)	(16)	(2)	(66)	(20)	(17)	(0)
	Percent		Percent		Percent		Percent	
Graminoids	77.2	88.8	63.4	72.5	69.9	84.8	84.7	-
Water Hemlock	3.5	4.2						
Pea	0.6	1.7	23.4	27.5			5.0	-
Galium	0.5	-	1.3	-	1.5	5.3		
Dead Vegetation	18.3	4.2	10.0	-	24.8	4.8	2.9	-
Silverweed							3.2	-
Moss					2.9	4.0		



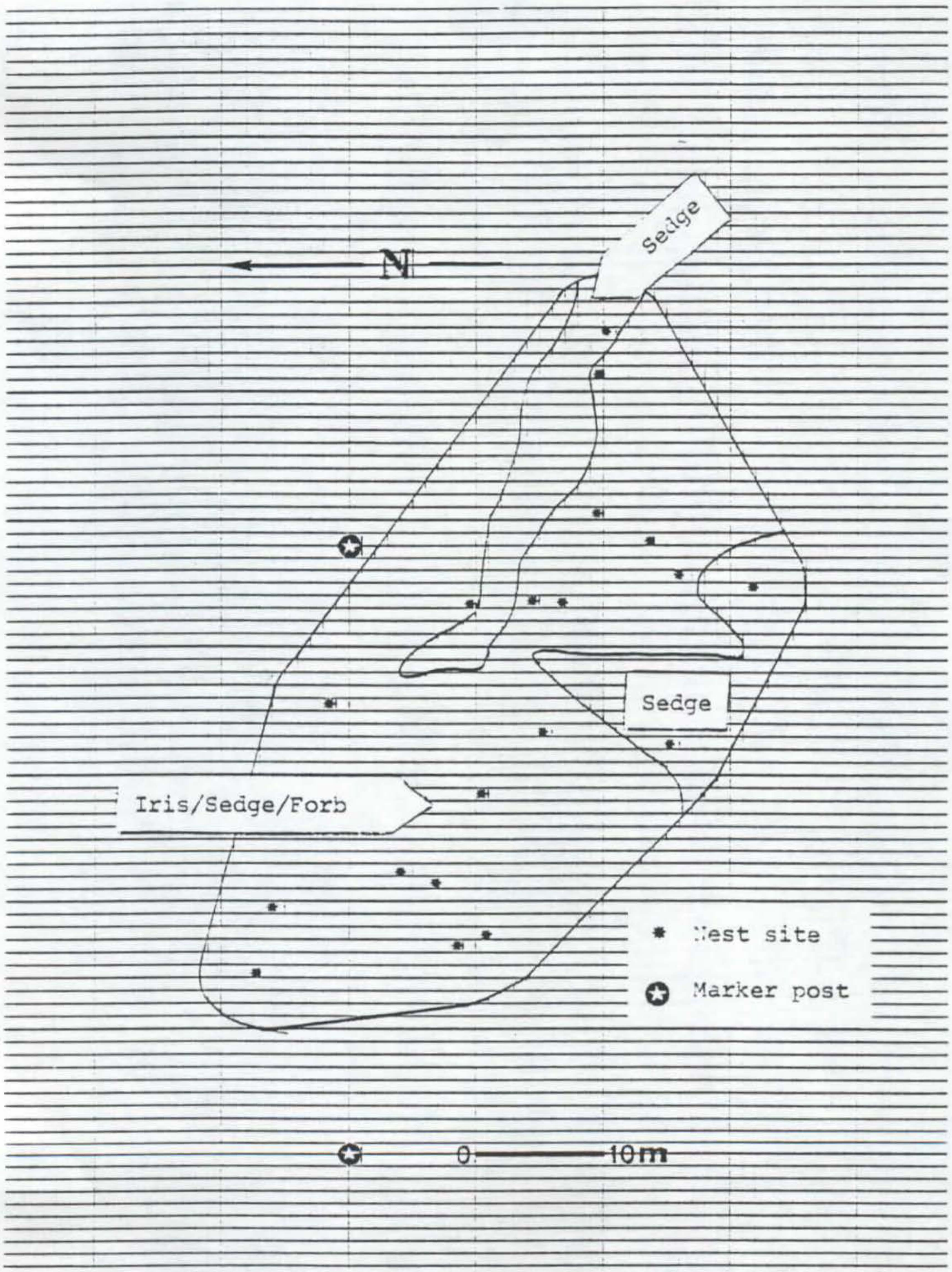
Appendix VI , Figure 1. Colony 1 vegetation map with the locations of Aleutian tern nest sites and marker posts.



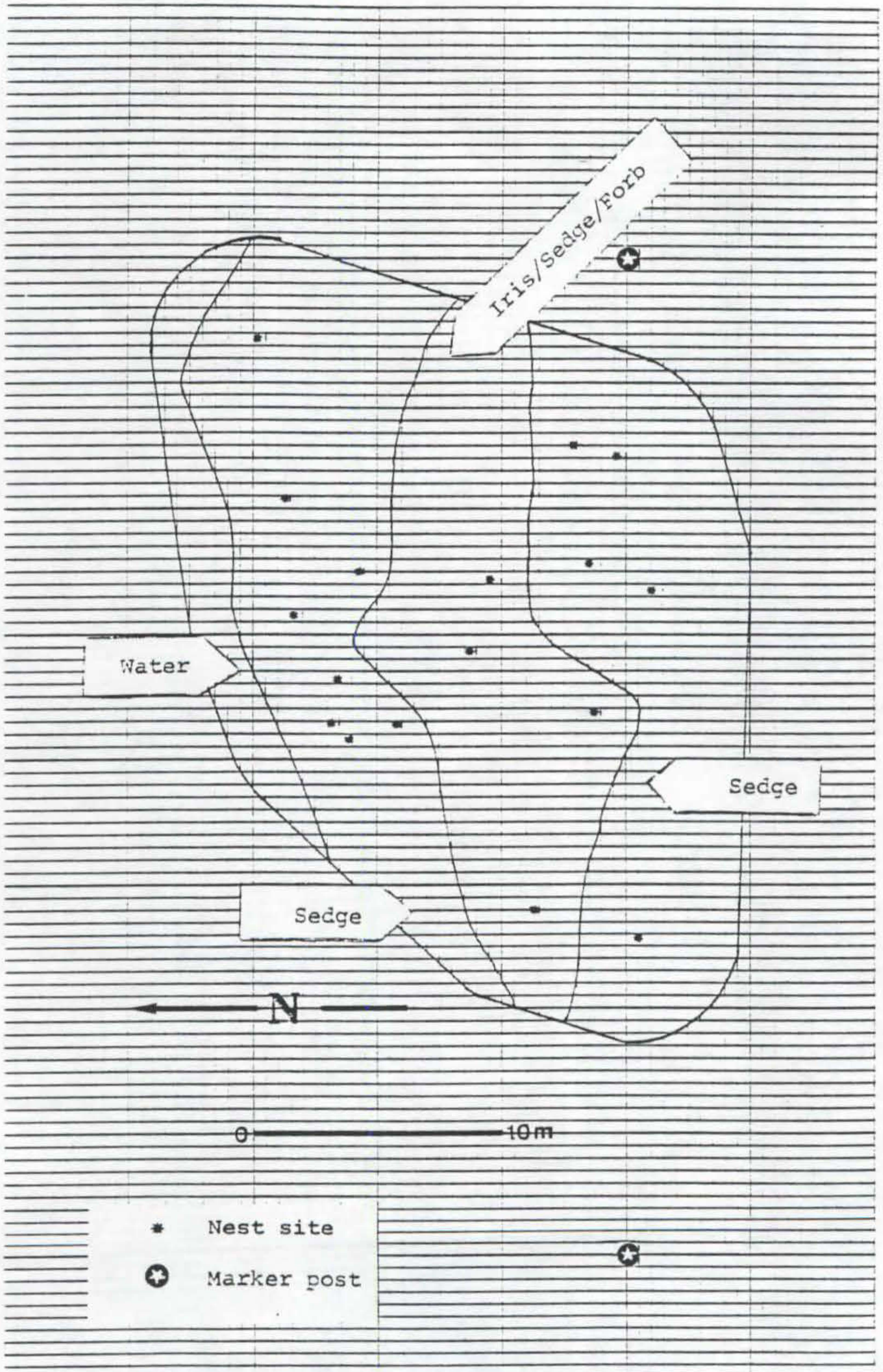
Appendix VI , Figure 2. Colony 2 vegetation map.



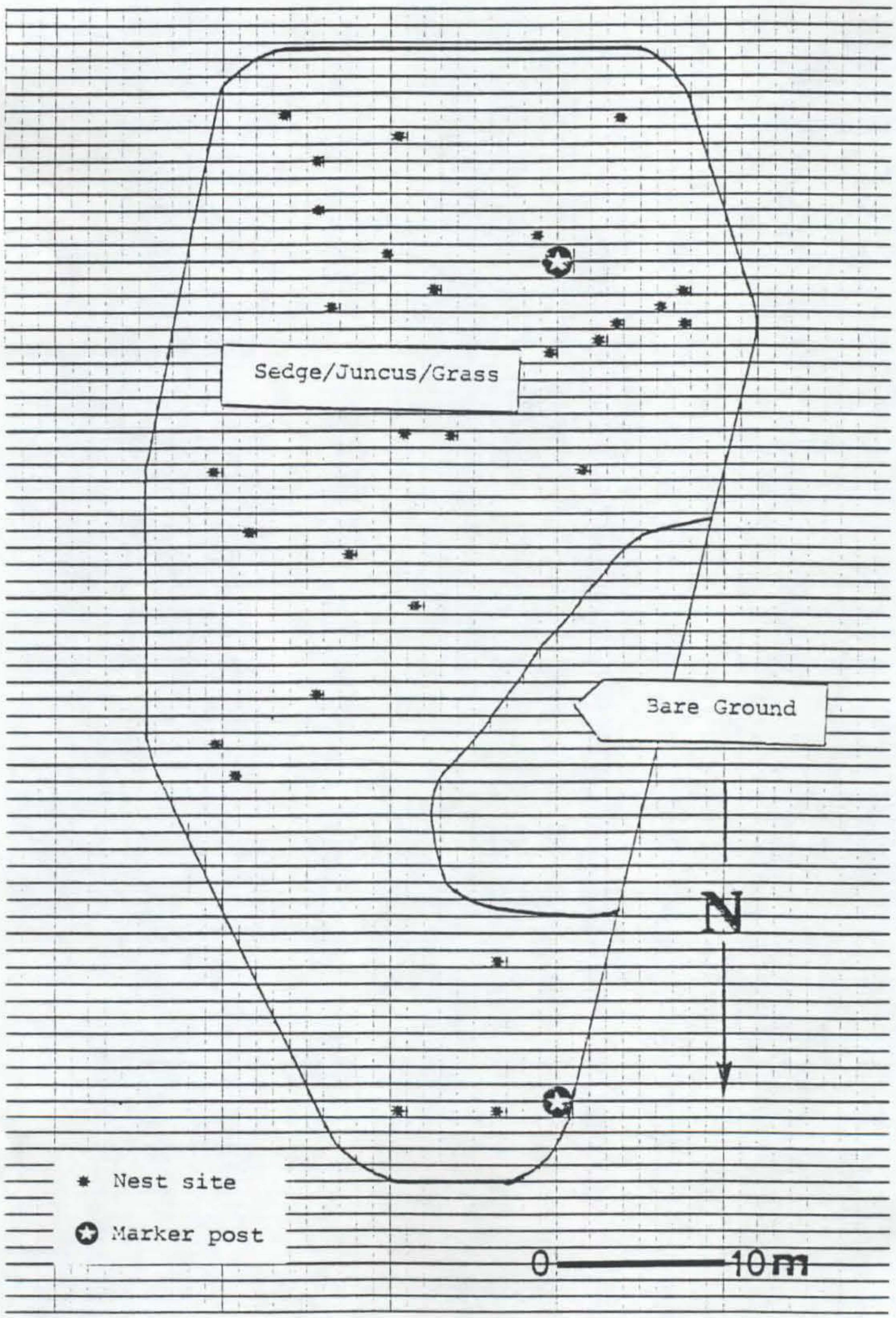
Appendix VI , Figure 3. Colony 3 vegetation map.



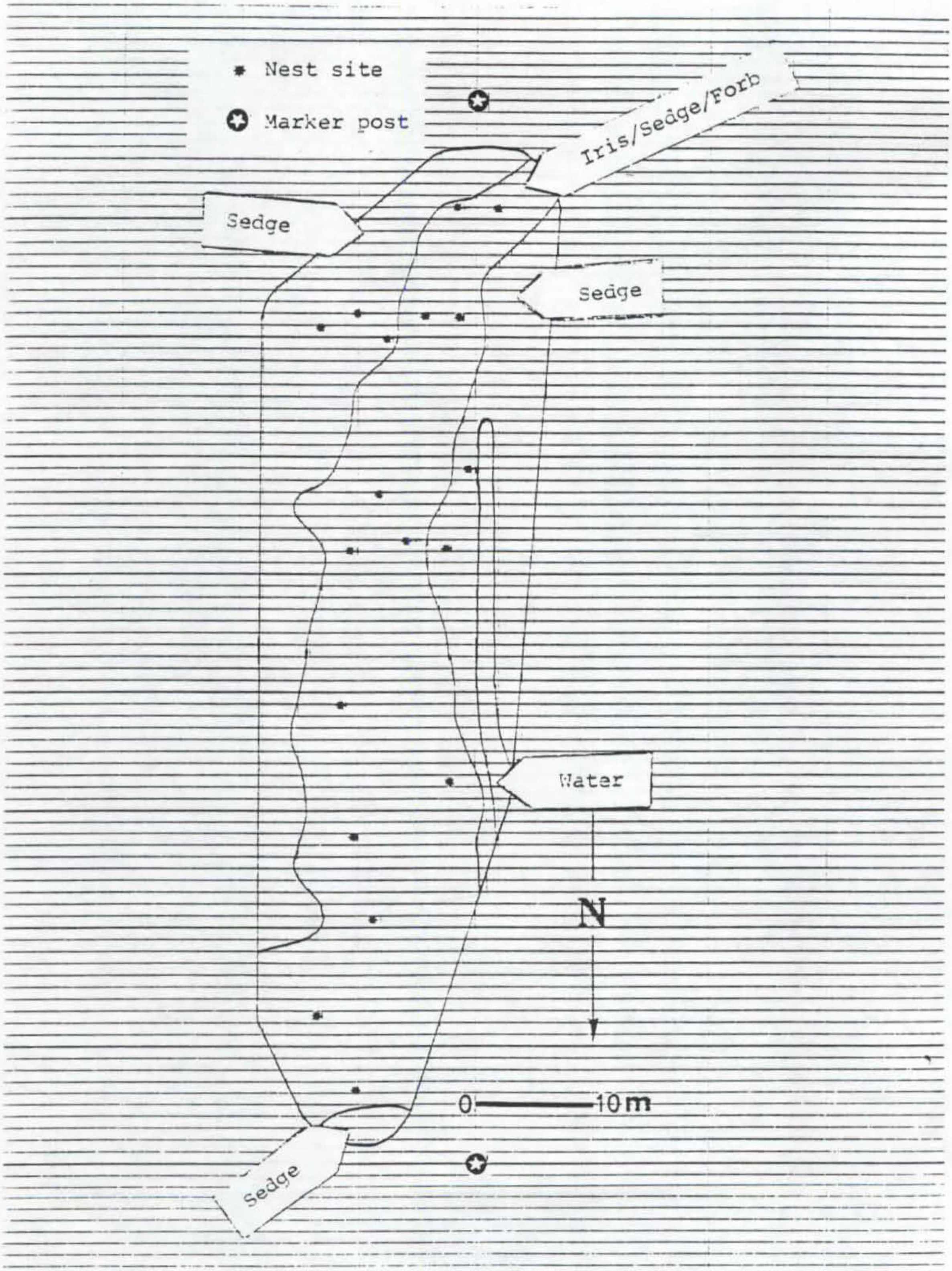
Appendix VI , Figure 4. Colony 4 vegetation map.



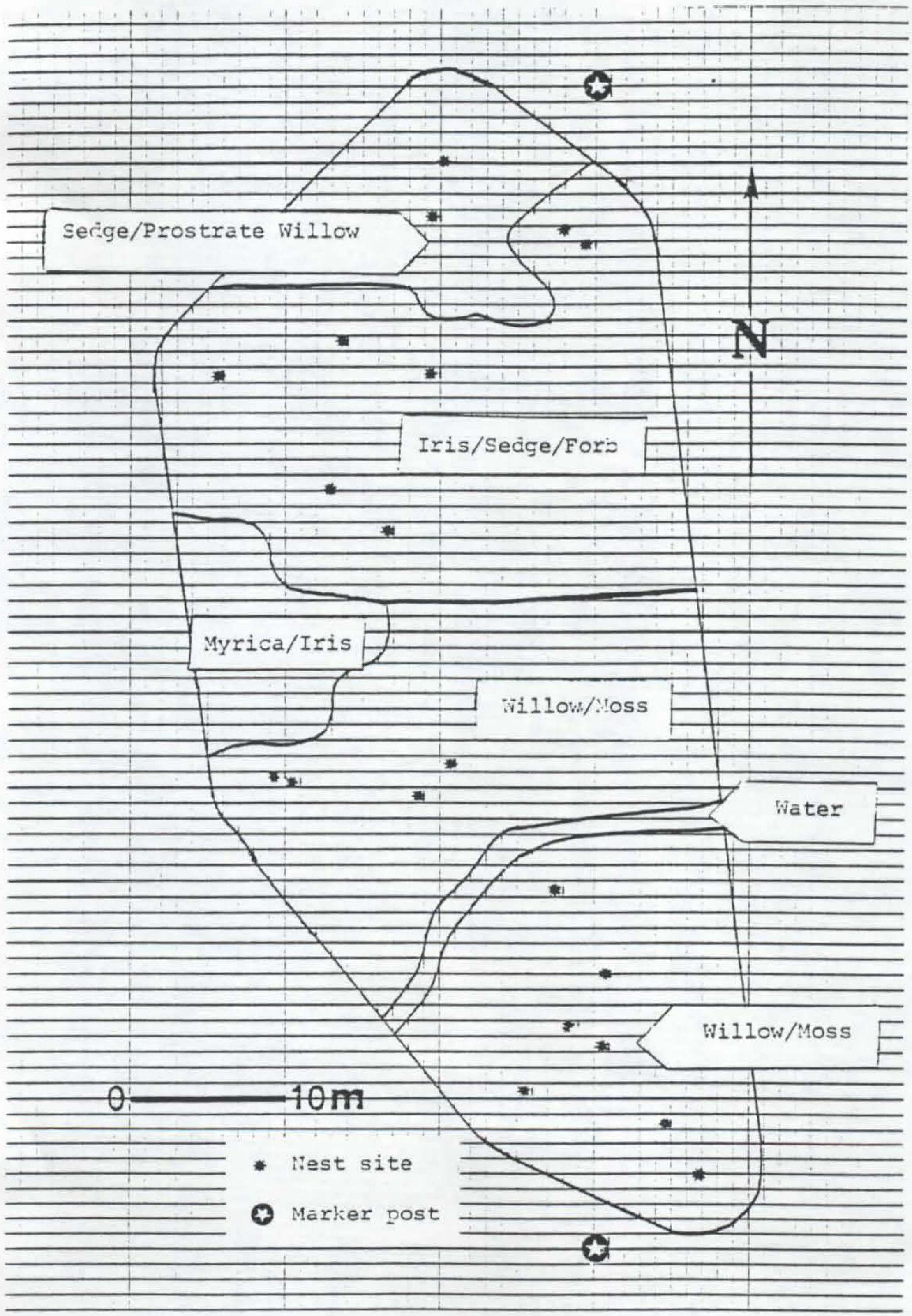
Appendix VI , Figure 5. Colony 5 vegetation map.



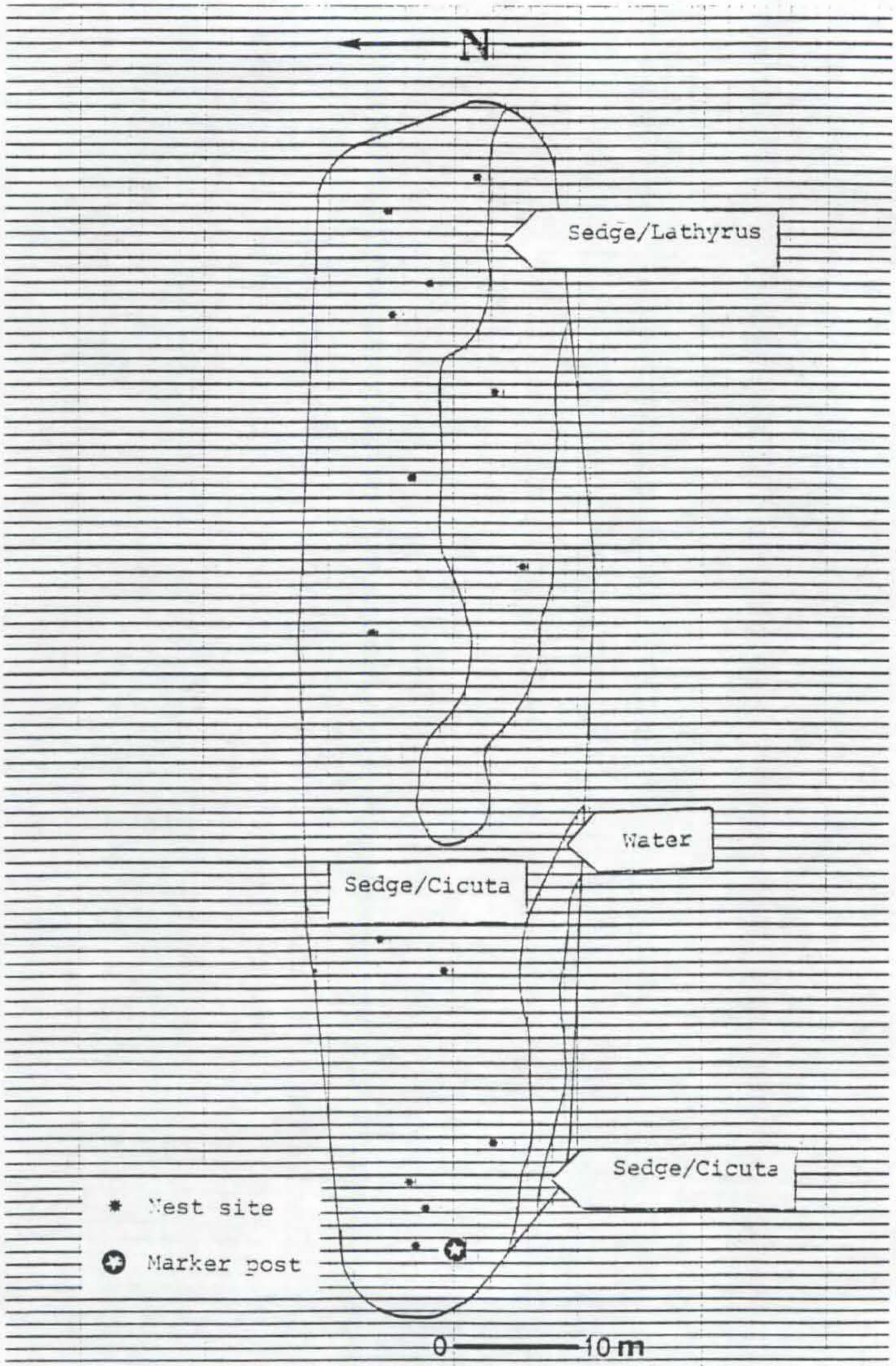
Appendix VI , Figure 6. Colony 6 vegetation map.



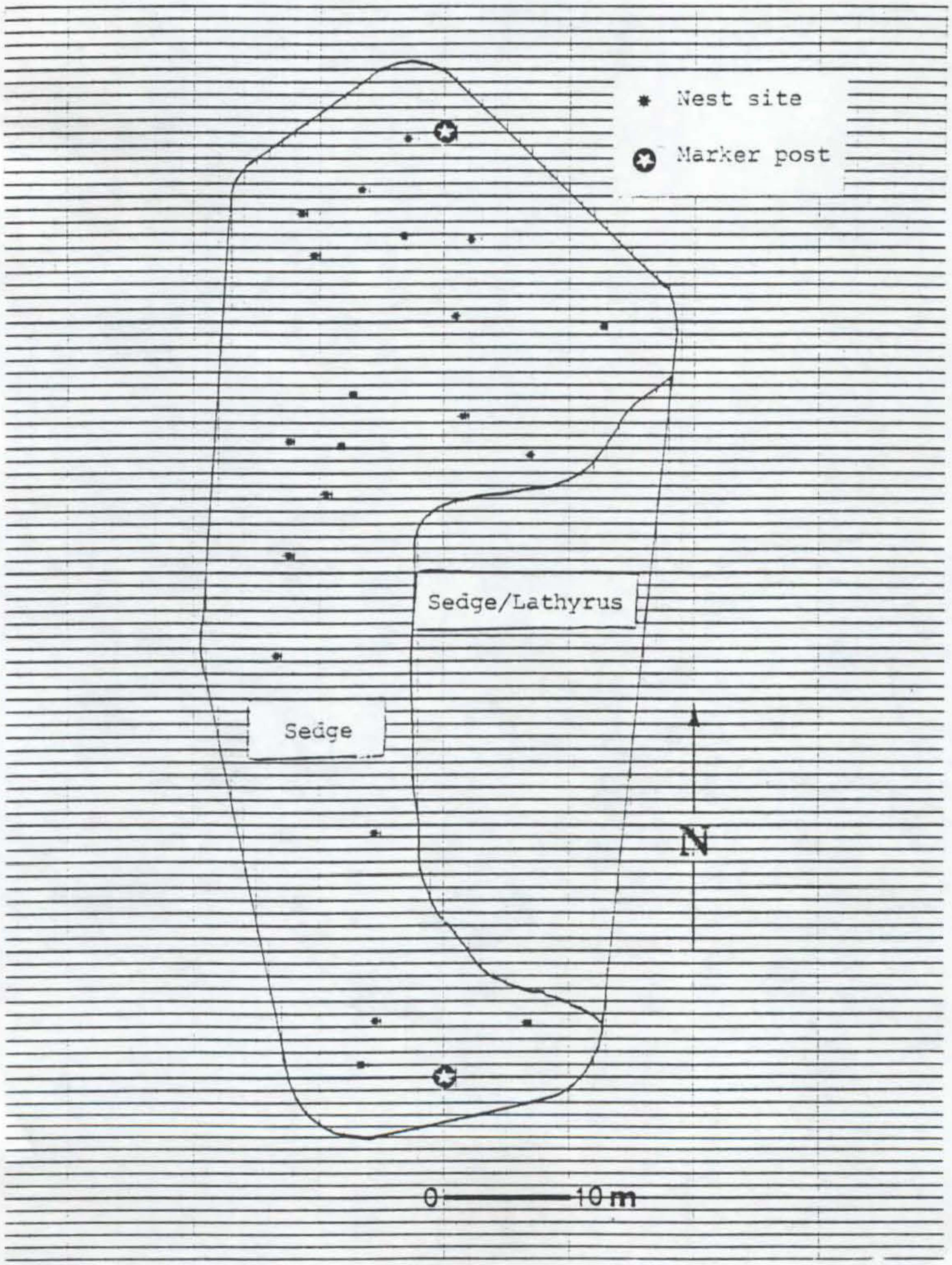
Appendix VI , Figure 7. Colony 7 vegetation map.



Appendix VI , Figure 8. Colony 8 vegetation map.

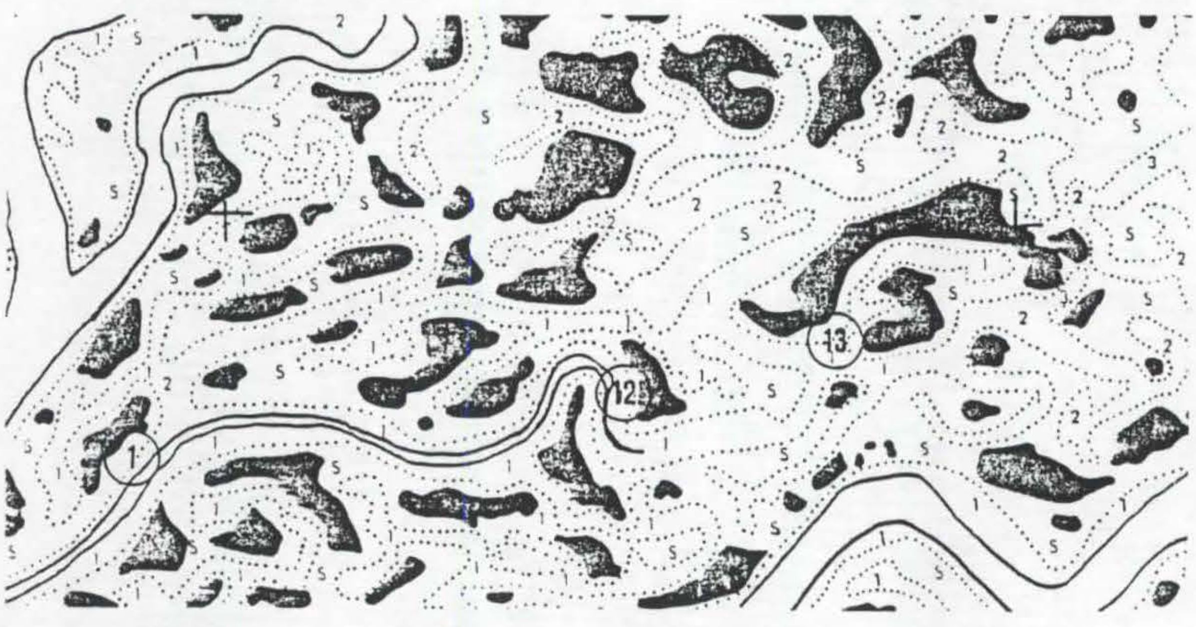


Appendix VI , Figure 9. Colony 9 vegetation map.

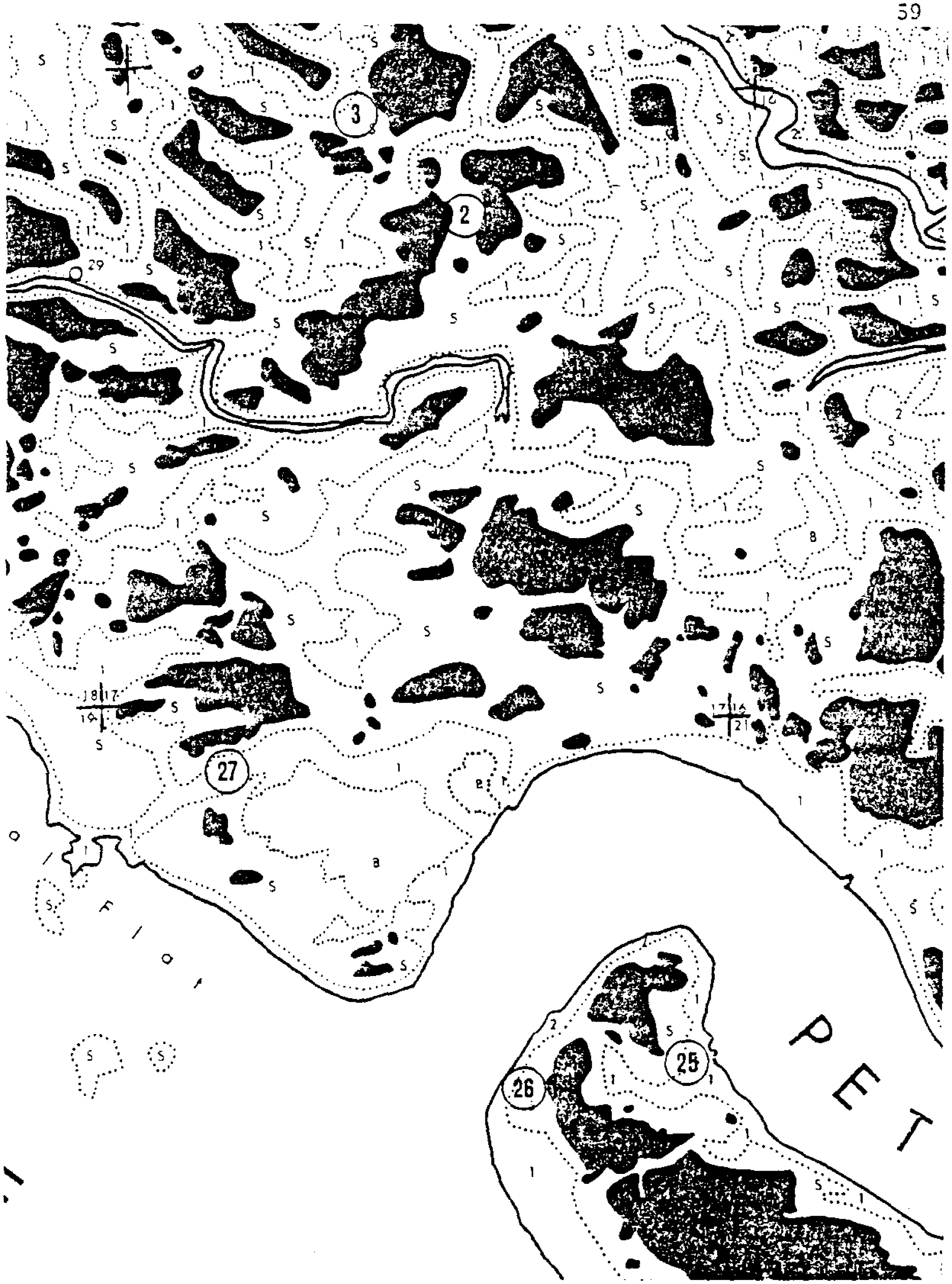


Appendix VI , Figure 10. Colony 10 vegetation map.

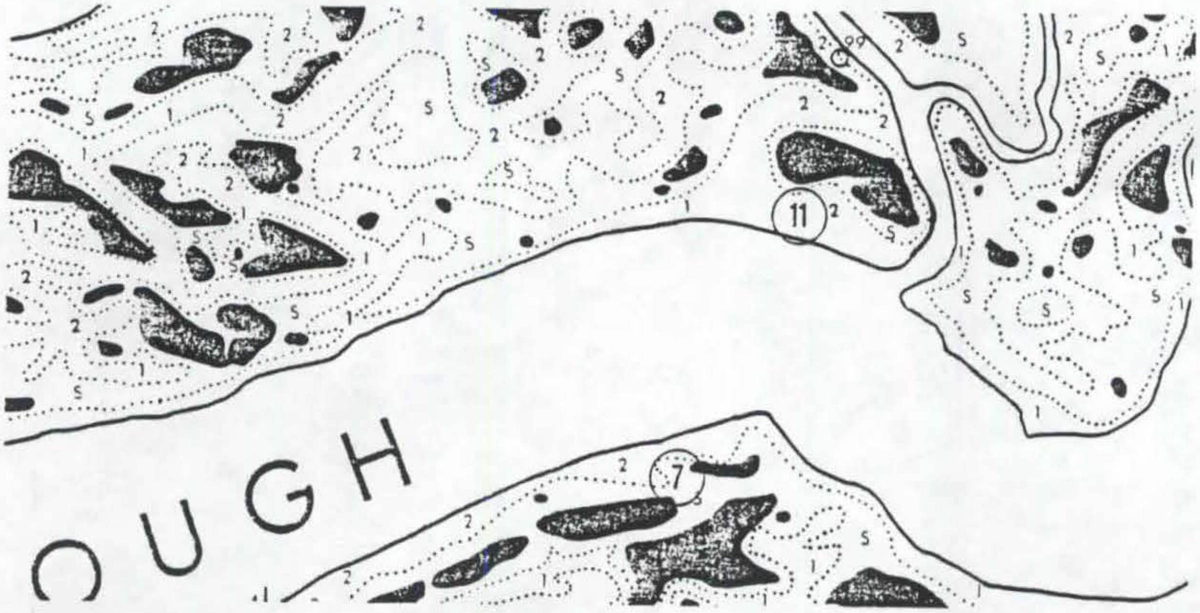
Appendix VII . Areas A-M showing the specific locations of colonies 1-34 on the west side of the Copper River Delta.



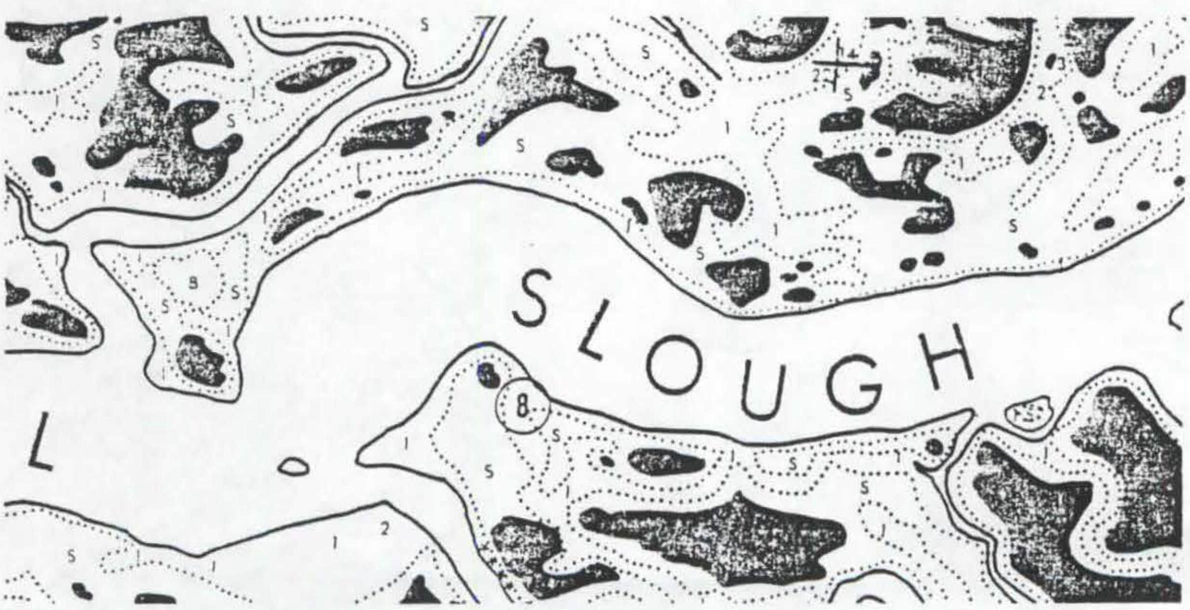
Appendix VII , Figure 1. Area A showing the locations of colonies 1, 12, and 13.



Appendix VII , Figure 2. Area B showing the locations of colonies 2, 3, 25, 26, and 27.



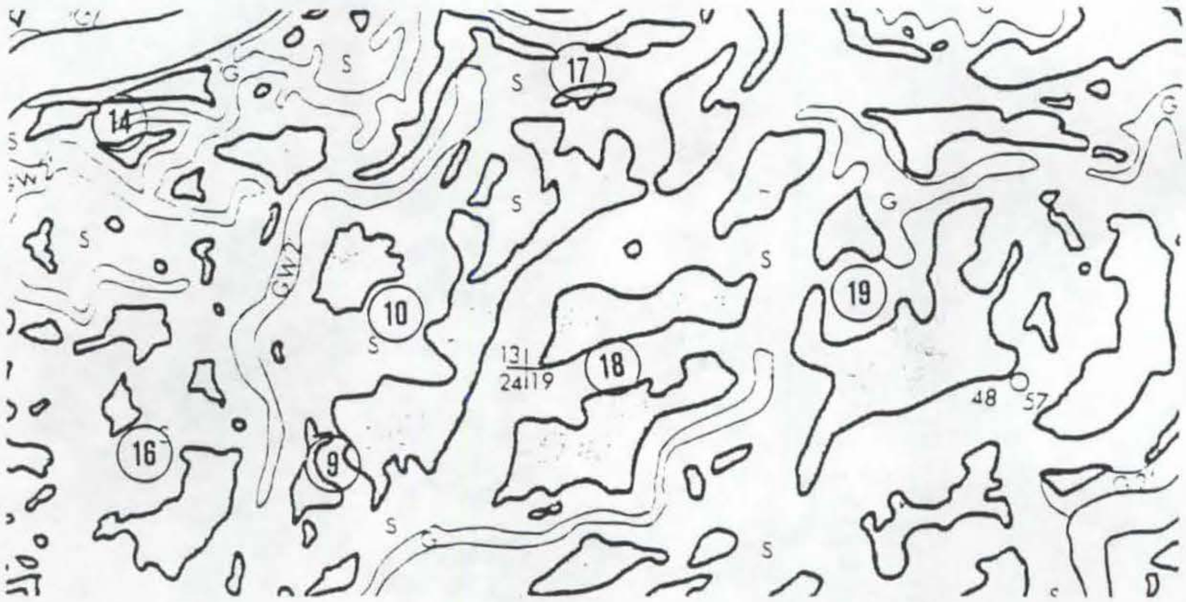
Appendix VII , Figure 3. Area C showing the locations of colonies 7, and 11.



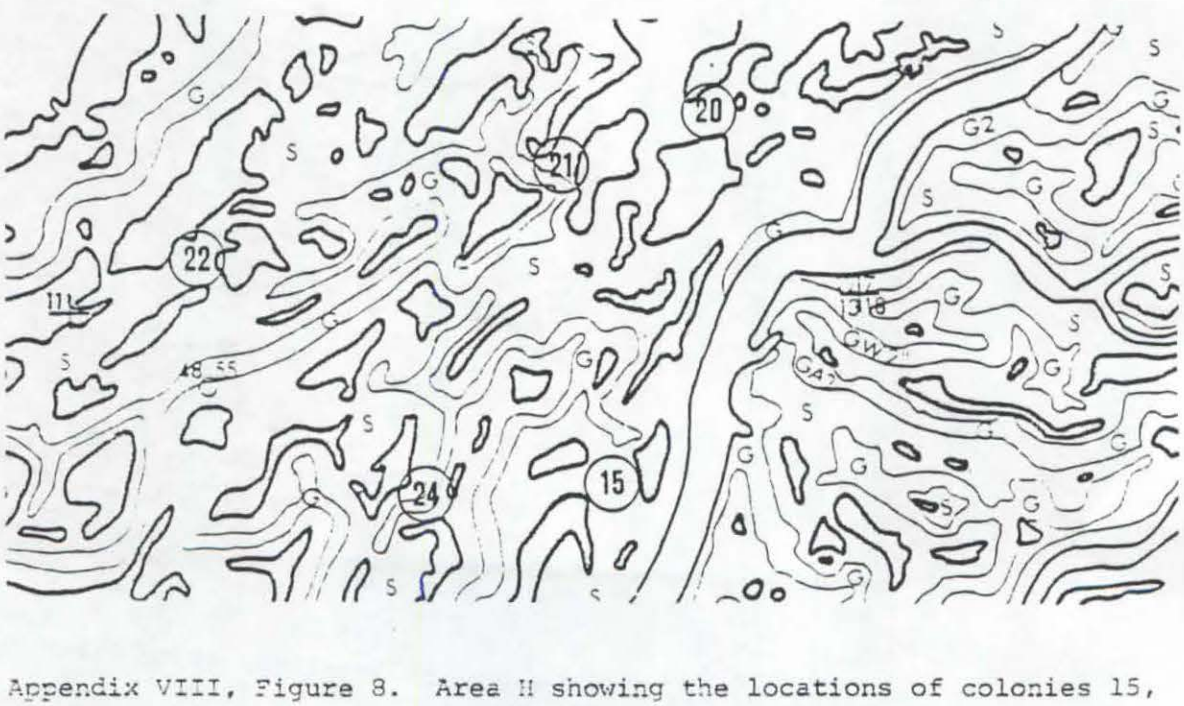
Appendix VII , Figure 4. Area D showing the location of colony 8.

Appendix VII , Figure 5. Area E showing the location of colony 29.

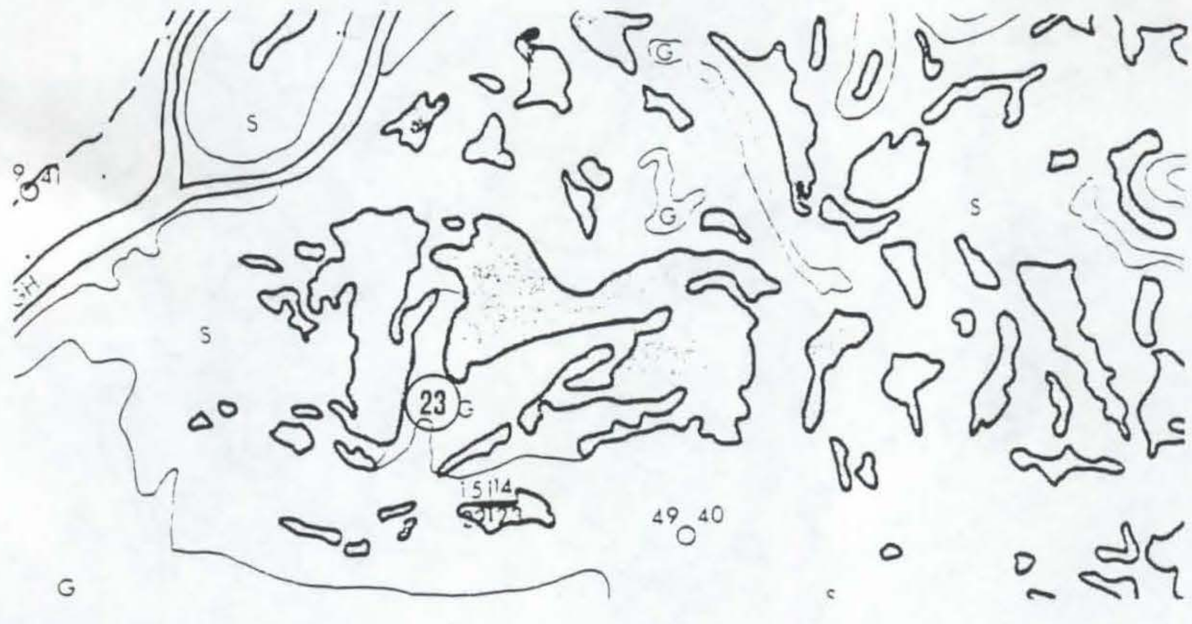
Appendix VII , Figure 6. Area F showing the locations of colonies 4, 5, and 6.



Appendix VIII, Figure 7. Area G showing the locations of colonies 9, 10, 14, 16, 17, 18, 19.



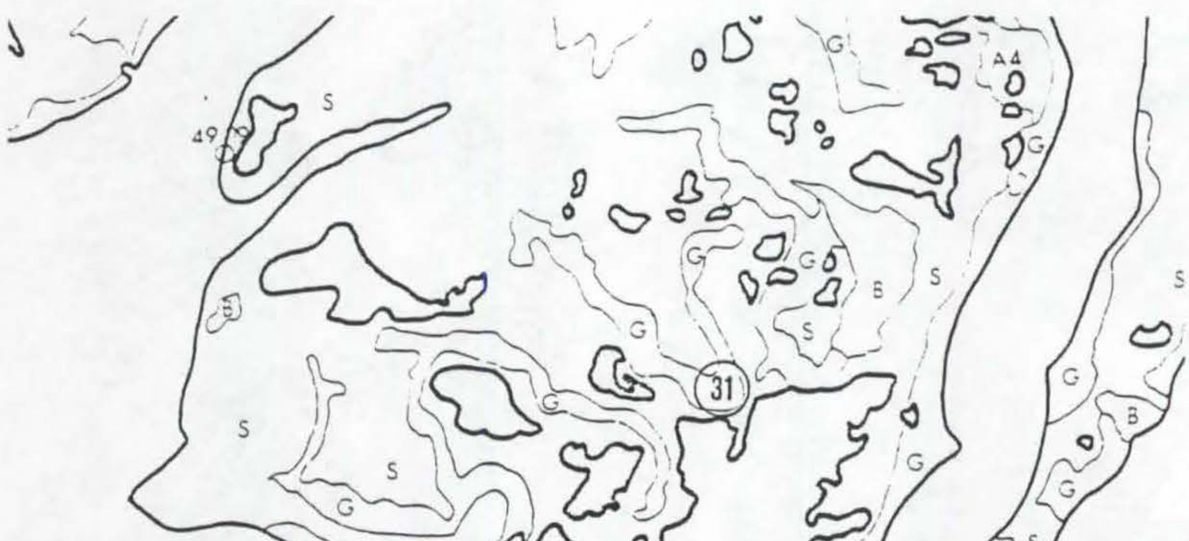
Appendix VIII, Figure 8. Area H showing the locations of colonies 15, 20, 21, 22, 24.



Appendix VII , Figure 9. Area I showing the location of colony 23.

Appendix VII , Figure 10. Area J showing the location of colony 30.

Appendix VII , Figure 11. Area K showing the location of colony 28.



Appendix VII , Figure 12. Area L showing the location of colony 31.

Appendix VII , Figure 13. Area M showing the locations of colonies 32, 33, and 34.

Appendix VIII. A list of plant species (after Hulten 1968) by vegetation zone in intensively studied Aleutian tern colonies 1-10.

Plant Species	Vegetation Zone: Sedge	Iris/Sedge/Forb	Myrica/Iris	Sedge/Juncus/Grass	Sedge/Cicuta	Sedge/Lathyrus	Willow/Moss	Sedge/Moss	Sedge/Prostrate Willow
Achillea borealis		x	x					x	
Agrostis alaskana	x	x		x					
Arctophila fulva	x								
Calamagrostis deschampsioides	x	x	x	x		x			
Calamagrostis nutkaensis	x	x	x	x		x			
Caltha palustris	x	x							
Carex lyngbyaei	x	x	x	x	x	x	x	x	x
Chrysanthemum arcticum		x	x						x
Cicuta douglasii	x				x				
Cicuta mackenzieana	x				x				
Deschampsia beringensis	x	x	x	x		x		x	
Dodecatheon pulchellum		x	x						
Epilobium spp.	x	x	x			x	x	x	x
Festuca rubra	x	x	x	x		x	x	x	x
Galium trifidum	x	x			x	x			
Gentiana spp.	x	x		x					
Hedysarum alpinum		x	x						
Hippuris vulgaris	x				x				

Appendix VIII. (Continued)

Plant Species	Sedge	Iris/Sedge/Forb	Myrica/Iris	Sedge/Juncus/Grass	Sedge/Cicuta	Sedge/Lathyrus	Willow/Moss	Sedge/Moss	Sedge/Prostrate Willow
	Vegetation Zone								
Hordeum brachyantherum		x							
Iris setosa		x	x				x		
Juncus arctica				x					
Lathyrus palustris	x	x				x			
Ligusticum scoticum		x	x						
Luzula multiflora				x					
Lysimachia thyrsiflora	x								
Myrica gale			x						
Parnassia palustris	x	x	x	x			x	x	x
Pedicularis sudetica		x		x					
Plantago macrocarpa		x	x						
Poa eminens	x	x	x				x	x	
Potentilla egedii	x	x	x	x	x	x	x	x	x
Potentilla palustris	x								
Primula egaliksensis		x	x	x			x		
Rhinanthus minor		x	x	x			x	x	
Rumex fenestratus		x	x						
Salix arctica	x	x	x	x			x	x	x
Salix barclayi							x		
Stellaria humifusa	x	x		x		x			

APPENDIX IX. DESCRIPTIVE ECOLOGY OF NESTING ALEUTIAN TERNS ON THE WEST SIDE OF THE COPPER RIVER DELTA

ARRIVAL

General Observations

On 25 April 1978 the arrival of Aleutian terns to the west side of the Copper River Delta was first noted by the brief observation of a few scattered pairs and individuals flying overhead in the general vicinity of a known colony. For the next 6 days (26 April-1 May 1978) singles and small groups of 2-5 Aleutians were occasionally seen or heard near, or passing en route to colony areas.

Habitat

An unusually mild winter was followed by an extremely early spring in 1978 on the Copper River Delta. During the first visits to the delta in mid-April all sloughs and ponds were ice free and no snow cover was evident except in areas close to the Copper River.

During the week following the arrival of Aleutian terns daily temperatures ranged from lows of 4-6^{o}C to highs of 7-12^{o}C. Little new vegetative growth was apparent in known colony areas during this time. The growth of sedge (Carex lyngbyaei), the most abundant plant species, was most extensive in very moist areas and along the edge of ponds where soil temperatures were 2 to 6^{o}C higher than drier, better drained areas. As an example, at a colony on 30 April 1978, sedge within 90 mm of standing water at 9^{o}C had attained a height of 70-250 mm, while sedge in 7^{o}C 10-15 mm water was 60 mm high. At the same colony, sedge had

only begun to sprout in the drier 5°C soil where Iris setosa was 50-85 mm high.

PRENESTING

General Observations

The loose attachment of Aleutian terns to colony sites appeared to strengthen gradually. By 2 May 1978 small numbers of birds were consistently present at colonies during the mid and late morning hours. Aleutian terns in flocks of 3-5 were seen chasing one another, often pursuing a bird carrying a small fish in its bill. From 3 May-6 May 1978 birds were beginning to spend time resting in fairly compact groups on the ground especially near the edge of ponds bordering the colony areas. Interactions between individuals were frequently observed as fish were either offered or begged, or as necks were "craned" upward. The stage of these courtship activities was demonstrated on 5 May when several copulations were observed.

Periodically, birds would burst into flight, rising en masse above the colony area. While any disturbance might elicit this behavior, it occurred both spontaneously with no initiating cause apparent to the observer, and seemingly in response to the arrival of another Aleutian tern. The swirling flock of Aleutian terns occasionally disappeared for as long as 5 minutes leaving the colony area completely vacant.

Despite the increased activity at the colonies in the morning, birds were seldom seen in colonies during the afternoon or evening until 7 May 1978. At this time pairs of birds became more dispersed over the colony area. An increased interest in nest sites was noticed as

individuals fluttered up and down in different locations occasionally picking at blades of sedge.

NEST INITIATION

On 10 May 1978 the first Aleutian tern nest was discovered. Within the next 3 days, 16 1-egg nests and only 1 2-egg nest were found, indicating that egg laying had just begun.

Searching for nests proved to be a very tedious and time consuming undertaking. Because the discovery of a well camouflaged egg was the only clue indicating the presence of a nest bowl, each searcher could confidently cover a strip of ground only 2 m wide.

During the 1978 breeding season, a total of 275 nests were located in the 19 colonies visited while incubation was still underway. Of 164 nests that were located within 9 of the 10 intensively studied colonies prior to 1 June 1978, 139 (84.8%) contained two eggs and 25 (15.3%) contained one egg. Only one 3-egg clutch was encountered during the 1978 breeding season. Nests found after 1 June 1978 were excluded from the above data since they may already have hatched one chick. Because it was impossible to identify a nest bowl prior to the laying of at least one egg, and because some 1-egg clutches were possibly the result of a partially predated 2-egg clutch, it is expected that the above data represents some bias toward a smaller clutch size.

In view of the above considerations and the high probability of overlooking a nest, it was difficult to determine the exact initiation date of any one nest. The most satisfactory results for estimating the initiation of laying were attained by backdating the date of first

hatching per nest by a calculated average incubation period. An average incubation time of 23 days was determined from 30 nests that were originally found containing one egg, had a second egg added to them, and successfully hatched the first egg. Incubation periods for the first egg ranged from 20 to 25 days. An average incubation period of 22 days has been reported for the associated arctic tern (Hawksley 1957, Coulson and Horobin 1975). Within 7 intensively studied colonies, calculated initiation dates for 119 nests that were known to hatch at least the first egg extended from 9 May to 27 May 1978. The 6 day peak initiation period from 12 May to 17 May 1978 accounted for 86 nests (72.3%) and appeared to be fairly synchronous for these 7 colonies (Figures 1 and 2).

Some nests were found late during the incubation period within less than 1 m of previously destroyed nests, indicating that Aleutian terns may be capable of renesting.

Aleutian terns apparently spend little time in the actual construction of a nest. A nest bowl consisted solely of a suitable depression in the vegetation and seemed to lack the incorporation of any additional materials. Individuals flushed from their nests while under observation always faced the same direction when alighting on their nests, giving the nest bowl an oblong shape. Measurements of 126 nest bowls averaged 111 mm in width and 38 mm in depth.

A total of 83 eggs were measured and averaged 43.5 mm long (SD=1.65) 29.6 mm wide (SD=0.67), with a weight of 19.6 g (SD=1.25). First eggs within 20 2-egg nests (length 43.9 mm, SD=1.53; width 29.9 mm, SD=0.56; weight 20.1 g, SD=1.2) averaged slightly larger and heavier than second

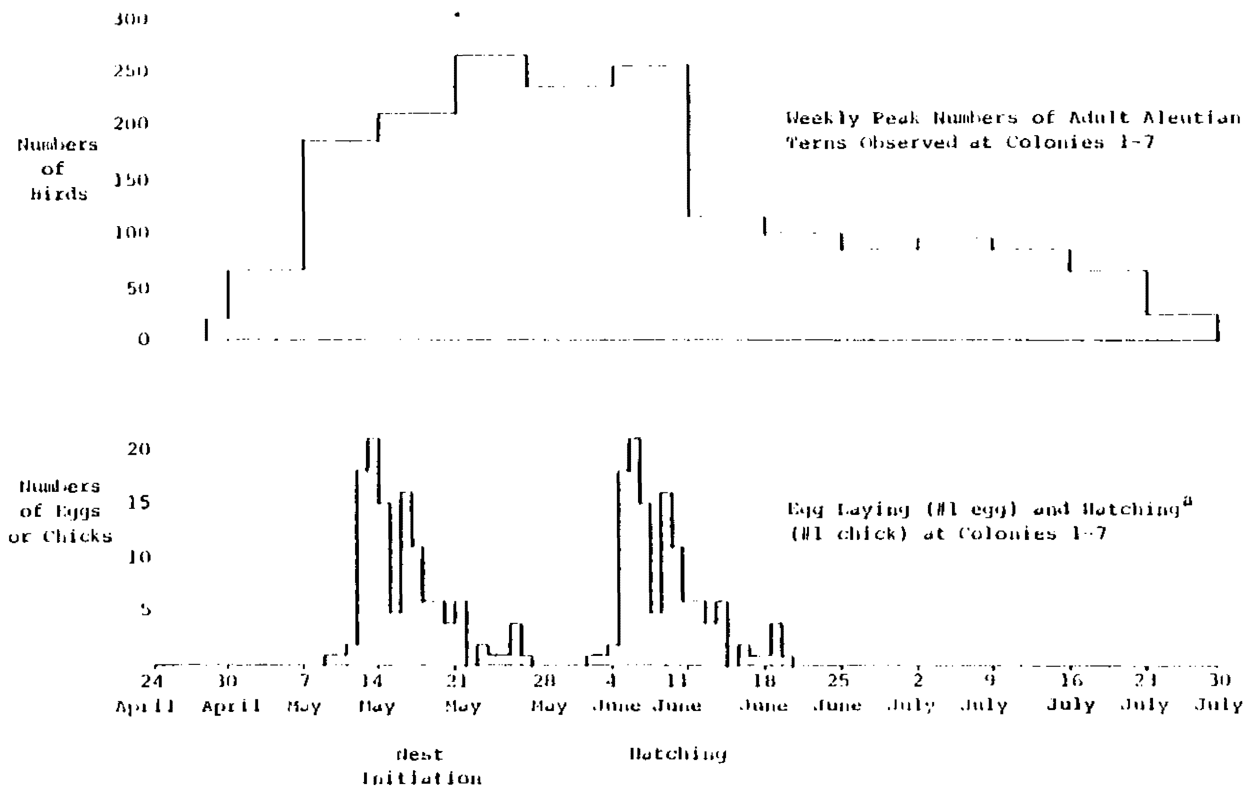
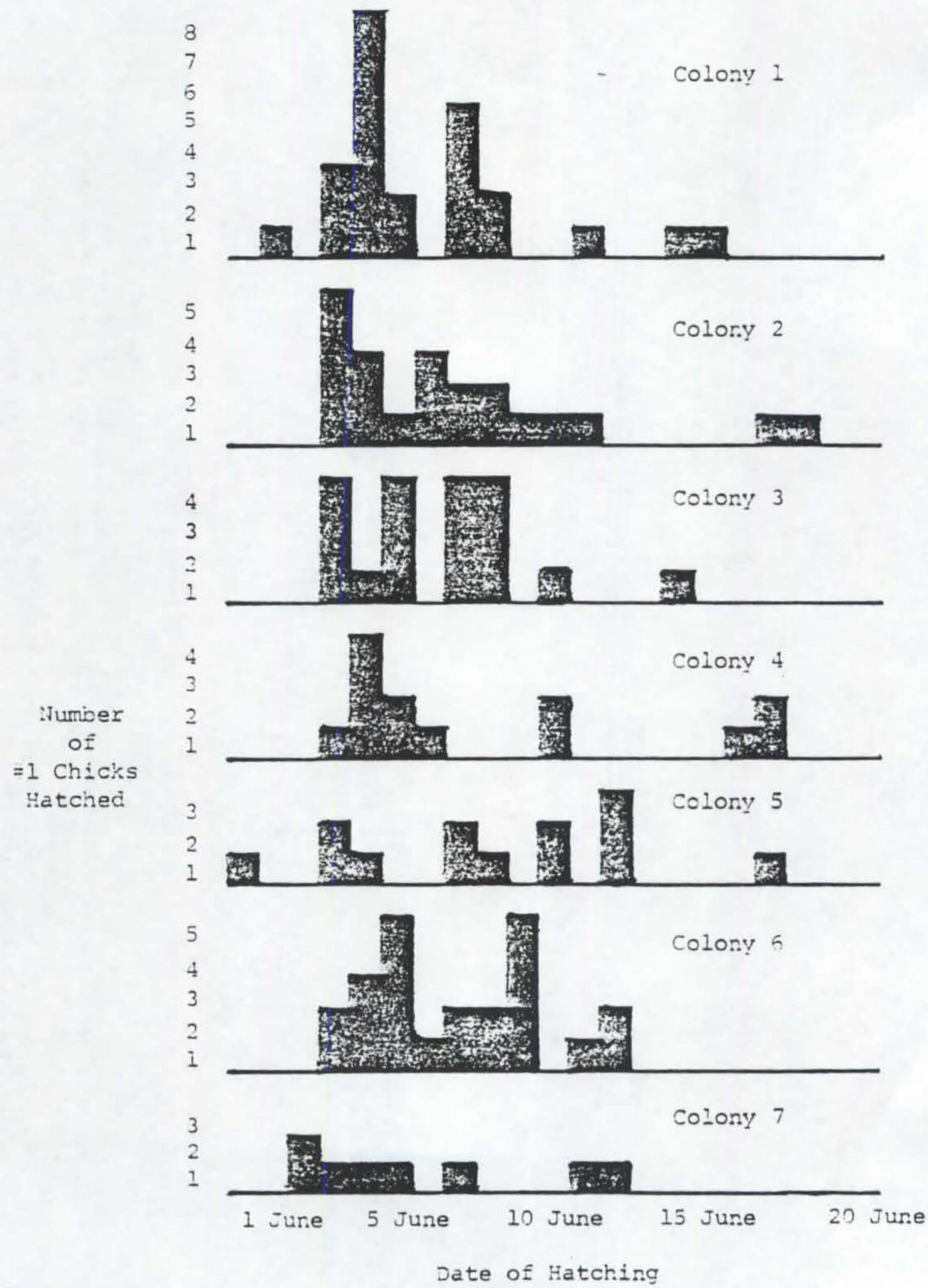


Figure 1. The weekly peak numbers of adult Aleutian terns that were observed and the laying of the first egg per nest and the hatching of the first chick per nest in intensively studied colonies 1-7.

[a] Initiation dates were calculated using a mean incubation period of 23 days from 30 nests for which both initiation and hatching dates were known.

Figure 2. The number and date of hatching of the first Aleutian tern chick per nest in intensively studied colonies 1-7.



eggs (length 43.2 mm, SD=1.82, width 29.6 mm, SD=0.55; weight 19.6 g, SD=1.09), although the difference was not significant ($\underline{P}<0.05$).

Habitat

With the exception of scattered clumps of the shrub *Myrica gale* in a few colonies and *Juncus arcticus* in a colony bordering the tidal mudflat, no residual cover from the previous year's growing season was present at the time of nest initiation. By springtime, the previous year's growth of *Carex lyngbyaei*, an abundant plant attaining heights of over 700 mm along pond edges, was flattened completely by winter winds and snow. Dead *Carex* comprised 72.2 percent of the area for samples taken at 94 nest sites from 10 May to 22 May 1978. Live *Carex* and moss were the most important plants composing the remaining area, but also iris (*Iris setosa*), prostate willow (*Salix arctica*), shooting star (*Dodecatheon pulchellum*), silverweed (*Potentilla egedii*), and *Plantago macrocarpa* were found in smaller amounts at this time. During the period from 10 May through 15 May 1978 live sedge had reached an average height of 76 mm and iris an average of 97 mm. By 22 May, live sedge averaged 117 mm and iris 147 mm for 45 and 24 nest site samples respectively.

HATCHING

Although hatching was first observed on 1 June 1978 and continued until 28 June 1978, the hatching of the first laid egg per nest (#1 chick) reached a peak level from 4 June to 9 June 1978 (Figures 1 and 2). On the average, the first egg per clutch hatched two days after pipping

commenced and one day after the egg had been pipped. All traces of the egg shell were removed from the nest bowl by the parents as soon as the chick freed itself from the egg. On a few occasions, nests were observed with a chick still struggling to extricate itself from the egg and portions of the shell had already been carried away by the adult. The egg tooth had disappeared usually by the 2nd or 3rd day after hatching.

During the post-hatch period 164 chicks were banded, providing some insight into the survival and growth of individuals. Hatching of 2-egg clutches occurred asynchronously with the 2nd chick emerging an average of 2.16 days after the hatching of the 1st chick in 51 nests (range 0-4 days). Although the interval between the hatching of 1st and 2nd chicks varies among different species of terns, asynchronous hatching was commonly reported (Langham 1972, Nisbet and Drury 1972, Nisbet and Cohen 1975). Chicks rapidly disappeared into the surrounding vegetation and were seldom found in the vicinity of the nest bowl after a few days. The number of #1 chicks found in the area surrounding 54 nest bowls declined rapidly on successive days with 47 (87.0%) still present the 1st day after hatching, 23 (42.6%) the 2nd day, 6 (11.1%) the 3rd day and none the 4th day. While the weights of #1 chicks averaged 14.9 g (n=74), 17.9 g (n=54), and 23.2 g (n=27) the first 3 days outside of the egg, #2 chicks averaged 14.1 g (n=38), 14.7 g (n=35) and 15.9 g (n=26), respectively. On 8 June 1978 the first dead #2 chicks were found in a few nest bowls preceded by daily losses in weight. Because it was suspected that frequent visits to colonies 1-7 may have been partially responsible for #2 chick mortalities, visits to

these colonies were suspended. Subsequent visits to control colonies 9 and 10 where observer disturbance had been minimal, however, revealed that the survival of chicks during the first few days following hatching was significantly lower in these colonies (Table 1). The reduced survival of 2nd hatched chicks was reported for common terns (Sterna hirundo), arctic terns, roseate terns (Sterna dougallii), and sandwich terns (Thalasseus sandvicensis) (Hawksley 1957, Langham 1972).

Habitat

Vegetation samples taken at nest sites from 4 June through 10 June 1978 indicated that considerable plant growth had taken place since nest initiation. At 110 nest site samples, the percent cover attributed to dead vegetation accounted for only 36.1 percent of the sample compared to 72.2 percent at nest initiation. An increase in the amount of live sedge was largely responsible for this change since nest initiation. The average height of live sedge had now attained 156 mm (n=81) and Iris setosa, 207 mm compared with the respective values of 76 mm and 97 mm at nest initiation.

FLEDGING AND DEPARTURE

After the completion of hatching, numerous attempts were made to locate Aleutian tern chicks in colony areas by systematic searches and with the aid of a dog. The weights and primary feather lengths, measured from the proximal end of the base to the tip of the longest feather, were recorded for any recovered chicks.

Table 1. The hatching success, average number of chicks hatched per nest and the number of dead chicks found at nest bowls per 100 nests for intensively studied Aleutian tern colonies 1-7.

Colony Location Number	Total Nests	Fate of Nests (%) Destroyed	Abandoned	Hatched	Unknown	Hatched Chicks per Nest	Dead Chicks per 100 Nests
1	28	10.7	3.6	85.7	0	1.39	21.4
2	32	12.5	0	75.0	12.5	1.16	28.1
3	25	4.0	12.0	84.0	0	1.28	24.0
4	20	10.0	10.0	70.0	10.0	1.05	15.0
5	15	0	6.7	86.7	6.7	1.27	26.7
6	29	10.3	6.9	82.8	0	1.28	20.7
7	16	18.8	18.8	56.3	6.2	0.88	12.5
TOTAL	165	9.7	7.3	78.2	4.8	1.21	21.8

Within a week following the period of peak hatching, counts of adult Aleutian terns present in colony areas declined significantly. Adults vacated the colony as soon as chicks were fed the food item they were carrying. Adults were very sensitive to the disturbance of observer presence in the colony at this time, and were reluctant to feed their young under such a condition. Observation of feeding activities, therefore, had little success in pinpointing chicks, because an adult with a fish might circle over the colony for long periods of time. Even with the aid of a dog, meticulous searches of the colony area only occasionally located chicks. The increased density of the vegetation and secretive behavior of highly camouflaged chicks prohibited any meaningful estimation of rate of fledging. Data collected from recaptured known-aged banded Aleutian tern chicks is presented in Table 2. Considerable variation in weights seemed to be attributable to differences in the growth rates of individuals but just as importantly to the amount of time elapsed since the last feeding. A 14 g Aleutian tern chick was encountered in the process of swallowing a 4.5 g fish. On another occasion, a 78 g chick regurgitated over 10 grams of food.

Although no fledging Aleutian terns were captured, primary feather lengths of 120 mm and 125 mm were measured on chicks that had almost gained flight during the time that fledging Aleutian terns were first observed in colony areas. The first fledgling was flushed on 27 June 1978, while peak numbers of flying immatures were counted on 8 July 1978. If these observations are related to peak levels of hatching, Aleutian terns were capable of fledging within 25 days plus or minus a few days. Arctic terns have been reported to fledge from 24 to 30 days after hatching (Hawksley 1957).

Table 2. The average weights and lengths of the longest primary feather of known age Aleutian tern chicks from hatching (day 1) to day 26 in intensively studied colonies 1-7.

Day	N	Weight (g)	Primary Length (mm)
1	74	14.9	--
2	54	17.9	--
3	27	23.2	--
4	7	24.6	--
6	1	38.0	--
8	1	46.5	20.0
10	1	62.0	--
11	1	77.0	30.0
14	1	74.0	45.0
17	3	86.0	68.3
19	3	108.0	90.0
20	1	106.0	85.0
23	1	117.0	120.0
24	1	81.0	105.0
26	3	91.3	100.7

A flush count of immature Aleutian terns was not a reliable basis on which to determine fledging success. Individuals might take flight at a distance of anywhere from 2 meters to 100 meters from the investigator thus giving inconsistent estimates for consecutive counts within the same area. I also suspected that young Aleutian terns left the colony area within a few days after gaining flight since proficient fliers never seemed to accumulate within a colony.

With the fledging of young, activity around colony areas diminished even further. Although adults attempting to feed a chick occasionally were joined and harassed by a diving, swirling group of 3-10 birds, the colony area gradually became only a sporadic focal point for terns. Toward the end of July, with the exception of infrequent passing individuals or small groups of adult Aleutian terns, most colonies were vacant.

USE OF PONDS

The association of Aleutian terns with ponds on the west side of the Copper River Delta was indisputable; however, the role that ponds played during the nesting season remained unclear. During the early stages of the prelaying period, Aleutian terns seemed to show a preference for congregating along the edge of ponds within the colony areas. At this time, Aleutian terns were frequently seen bathing in ponds at colony sites singly and in groups as large as 10. After "fish-carrying" adult Aleutian terns had fed their young, they were occasionally seen bathing in colony ponds. This may have been important in cleaning from their feathers the salt or glacial silt that had accumulated during plunges at offshore feeding areas.

Despite the many hours of observation, Aleutian terns were seen only rarely to plunge after fish in ponds. The constant fishing in these areas by Arctic terns (Sterna paradisaea) indicated the presence of a food supply. Three-spined sticklebacks (Gasterosteus aculeatus) were also trapped in abundance in many of the ponds. On a few occasions after the fledging of young, adult and immature Aleutian terns were seen "hawking" for insects close to the surface of colony ponds.

PREDATION

Levels of predation of eggs seemed low considering the number and diversity of predators that frequented colony areas. Although no actual occurrences of predation were observed, the presence of predators in colonies, the disappearance of eggs from nest bowls, and the location of fragments of shells provided coincidental evidence. Conclusive signs were not apparent in order to identify the particular predators that were responsible. It was also impossible to determine the degree of predation that took place after a nest had already been abandoned.

Except for the dead chicks that were found in the vicinity of nest bowls (Table 1), the fate of chicks remained unknown. However, the lack of success in finding young chicks, and the reduced number of adults observed at colony areas after the completion of hatching seemed to indicate a high level of predation on chicks.

Members of the entire colony would immediately rise up, attack and attempt to drive out any intruding avian predators. Despite this united and concerted effort of diving at the predator, parasitic jaegers (Stercorarius), short-eared owls (Asio flammeus) and glaucous-winged

gulls (Larus glaucescens) often continued searching in colony areas. Mew gulls (Larus canus) and arctic terns (Sterna paradisaea), more aggressive species nesting within and adjacent to Aleutian tern colonies, frequently joined the Aleutian terns in "mobbing" a predator. Although suspected of preying on tern eggs, mew gulls were tolerated to a certain extent and permitted to nest within some of the Aleutian tern colonies. An unusually high number of 4 mew gull nests was found in and bordering Colony 7. While other species of tern have been known to become habituated to avian predators nesting near or within their colonies (McNicholl 1973), the consequences of such an association could be either beneficial or detrimental. A benefit of protection has been attributed to nesting in association with a more aggressive species (Cullen 1960, Langham 1974). In contrast, increasing numbers of gulls have both brought increased predation of tern chicks (Hatch 1970), and the displacement of terns from colonies by disturbing normal nesting behavior (Crowell and Crowell 1946).

On 8 May 1978, a raven (Corvus corax) was observed stealing an egg from a goose nest within Colony 7. Ravens were occasionally seen early and again later during the breeding season in the vicinity of most of the intensively studied colonies. Daily feeding movements of glaucous-winged gulls nesting on the offshore barrier islands crossed several Aleutian tern colonies. Immature glaucous-winged gulls were observed making persistent but unsuccessful dives at a tern nest. The following day the nest was found empty.

Short-eared owls, only infrequently sighted during the summer of 1977, were present in abundance during the 1978 field season. This was

apparently in response to a population eruption of voles (Microtus oeconomus) on the delta in 1978. While no voles were seen during 1977, walks along better drained areas would often send voles scurrying in all directions in 1978. Portions of levees were completely denuded of vegetation in some areas as a result of grazing by voles. The high vole population may have been important in reducing predation of tern eggs and chicks by acting as a buffer species. Owl pellets, coyote (Canus latrans) and brown bear (Ursus arctos) scats were found heavily laced with vole remains in and near colony areas.

On 28 June 1978 a mink (Mustela vison) den was located 0.4 km from Colonies 2 and 3. Piled in the entrance way were 3 fledging arctic terns, 1 fledging mew gull and 2 voles, all freshly killed. On 17 June 1979 another mink den containing 18 voles, 2 fledging goslings and 1 fledging mew gull (all intact) was located 0.2 km from abandoned Colony 28. Brown bears were observed in 4 colony areas and fresh sign was seen in 4 other colonies. While doubtful that the bears were specifically attracted to the colonies, it seems likely that incidental predation of tern eggs and young occurred during searches for other food sources.

HUMAN DISTURBANCE

The reaction of Aleutian terns to human intrusion was quite different from the defensive behavior elicited by the entrance of an avian predator into the colony area. At the approach of a human, the birds would be flushed into the air, rising higher and higher, circling and dispersing until they were mere specks above the colony. For this

reason, it was impossible to selectively disturb one nest or one segment of the colony at a time.

The extent of human disturbance, however, was difficult to assess. Predators did not seem to take advantage of the periods when Aleutian terns were away from their nests during human disturbance, nor did they appear to use nest markers to key on nests. The overall low occurrence of predation of nests seemed to substantiate this observation. Some primary concerns of disturbance were related to the possibility of increased stress on nesting adults, the dispersal of young from nesting or feeding sites and an increase in abandonment of eggs or young. Most of these could not be assessed.

FORAGING AND PREY SPECIES

Unfortunately, few opportunities were available to observe Aleutian terns feeding. Birds were frequently seen flying towards the ocean and returning to colony areas carrying food items. Observations and reports from local fishermen confirmed the presence of foraging Aleutian terns along the edges of offshore channels and within the shallows of barrier islands 0.4 km to 9.7 km from the vegetated edge of the delta.

Only rarely were Aleutian terns seen fishing in the freshwater ponds of the delta. During the prelaying period, an Aleutian tern was observed catching a small fish in a pond adjacent to a colony. After the fledging of young, groups of birds, both immatures and adults, were occasionally seen catching small insects near the surface of a few colony ponds.

The identification of food items protruding or regurgitated from the mouths of chicks or dropped in the vicinity of nest bowls or feeding areas provided the most specific information on food preference. Threespined sticklebacks, Gasterosteus aculeatus, were the most abundant prey species found scattered near nest bowls and feeding areas. At Colonies 9 and 10 in the Eyak River area, large numbers of sticklebacks, 20 in one group, littering the ground seemed to question the ability or desire of young Aleutian terns to accept this spiny prey. The three-spined sticklebacks collected at nest bowls were much larger, averaging 79 mm (n=30) than the largest sticklebacks trapped in the freshwater ponds of the west side of the Copper River Delta. The average size of the largest sticklebacks encountered in these ponds (including only fish 40 mm or longer) was 49 mm (n=50). The smaller sticklebacks from the ponds also lacked the keel and scutes extending to the tail that were characteristic of the fish at nest bowls. The sticklebacks utilized by the Aleutian terns were therefore suspected of being from an anadromous population returning to the area to spawn. Salmon smolts (Oncorhynchus nerka and Oncorhynchus gorbuscha) ranging in size from 70 to 85 mm, stichaeids, sandlance (Ammodytes hexapterus) and shrimp found in colony areas verify the importance of offshore feeding areas. In addition, Aleutian terns may feed opportunistically on a wide variety of prey items including dragon flies, Aeshnidae, which were regurgitated by young.